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Air Force Assignment Data Analysis Report

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Risk assessors are often forced to use default, single point, assumptions of typical duration of exposure when performing risk assessments for military populations and their families due to the uncertainty of assignment tour lengths. This project uses a probabilistic approach to risk assessments to provide site specific time on station (i.e., residence time) distributions for both officer and enlisted personnel located at Air Force installations within the continental United States (CONUS). Five distinct assignment dates were investigated to evaluate temporal variations in residence time. A total of 369 spreadsheets containing 733 time-on-station distributions were prepared. Across all five data sets (1987, 1990, 1995, 1998, and 1999) the mean residence time on station was 915 days (2.51 years) for enlisted personnel and 692 days (1.90 years) for officers. This resulted in a factor of 3.59 and 4.74 less, respectively, than the default value of 9 years used by the U.S. Environmental Protection Agency (EPA). Human health risk estimates using a benzene inhalation exposure scenario in a Monte Carlo simulation, were found to be lower than the EPA mean risk estimates by factors of approximately 4 and 5 for enlisted and officer personnel, respectively.

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TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY 1

INTRODUCTION 2

Background 2

Current Effort 3

METHODS 4

Initial Screening of Input Data 4

Development of Time-on-Station Distributions 5

Development of Dependent Age Distributions 6

Inclusion of Additional Data Sets 6

RESULTS AND DISCUSSION 9

Summary Statistics 9

Analysis of Time-on-Station Distributions 10

Analysis of Dependent Age Distributions 10

Temporal Analysis of Time on Station Distributions 12

Analysis of Age, Grade, and Number of Dependents 15

Probabilistic Risk Estimates 15

CONCLUSIONS AND RECOMMENDATIONS 18

Population Mobility 18

Effect of Site-Specific Data on Probabilistic Risk Estimates 18

Recommendations for Further Study 18

REFERENCES 20

Page

APPENDIX A Time on Station Distributions, Summary Statistics and Dependent Age Distributions for Dover AFB, Edwards AFB, Elemendorf AFB, Maxwell AFB, and Minot AFB 21

APPENDIX B Summary Statistics for Enlisted and Officer –1999 35

APPENDIX C Probabilistic Risk Estimates 41

APPENDIX D Data Set Analysis Process 69

APPENDIX E Analysis of Additional data Sets 1987, 1990, 1995, 1999 Summary of Total Records Available, Enlisted and Officer Personnel Assigned to and Located at CONUS and PACAF Bases 75

APPENDIX F List of Symbols, Abbreviations and Acronyms 79

LIST OF FIGURES

Figure 1. 1998 Assignment Data, Enlisted Personnel (ASCII Text) 2

Figure 2. Enlisted Data Table Imported from ASCII Text File 4

Figure 3. Sample 1998 Enlisted Assignment Data Table 5

LIST OF TABLES

Table 1. Two-Letter Military Personnel Flight (MPF) Records in Additional Data Sets 8

Table 2. Best Fit Distribution Type - Gamma 11

Table 3. Best Fit Distribution Type - Weibull 12

Table 4. Best Fit Distribution Type - Beta 13

Table 5. Days on Station Summary Statistics 14

Table 6. Average Age, Grade, and Number of Dependents 15

PREFACE

This report was prepared by Operational Technologies Corporation (OpTech), 1370 North Fairfield Road, Suite A, Beavercreek, OH 45432 under Contract Number GS-35F-4519G, Order Number T0799BG0778. The data analysis effort was initiated on June 15, 1999 and completed by December 31, 1999 under the combined program management of Mr. Erik Vermulen and Dr. Peter Lurker. Captain Victor Caravello of the Air Force Institute for Environment, Safety and Occupational Health Risk Analysis, Environmental Sciences Branch (AFIERA/RSRE) served as contract monitor.

The senior analyst/author, Mr. Denny Reed would like to extend his appreciation for the technical assistance and direction provided by Captain Caravello and Mr. Cornell Long of AFIERA/RSRE. In addition, Master Sergeant Buckman and Technical Sergeant Tolle of the Headquarters, Air Force Materiel Command, Personnel Directorate, Data Automation and Analysis Branch (HQ AFMC/DPZD) went the extra mile in providing the Air Force-wide military personnel data in a timely matter. The technical support provided by Ms. Elaine Merrill of OpTech in carefully explaining the workings of the Crystal Ball® software is also gratefully acknowledged.

AIR FORCE ASSIGNMENT DATA ANALYSIS

EXECUTIVE SUMMARY

This report describes the analysis of Air Force assignment data that was performed for the Air Force Institute for Environment, Safety and Occupational Health Risk Analysis, Environmental Sciences Branch (AFIERA/RSRE), 311 Human Systems Wing, Aeronautical Systems Center, Air Force Materiel Command, Brooks Air Force Base, Texas. The data analysis described in this report was performed under Contract Number GS-35F-4519G, Delivery Order Number T0799BG0778, Task Order Number FE579006. The title of the task is "Military Housing Statistics for Risk Assessment Program Support". The primary purpose of this task was to derive time on station (i.e., residence time) distributions for both officer and enlisted personnel located at Air Force installations within the continental United States (CONUS). These distributions provide site-specific residence time data to support human health risk assessments at military (Air Force) facilities using the probabilistic (Monte Carlo) approach. Commercial off-the-shelf (COTS) software (i.e., Microsoft (MS) Access®, MS Excel®, and Crystal Ball® [Decisioneering, Version 4.0]) was used to analyze the data and prepare the electronic data deliverables.

Five distinct assignment dates were investigated to evaluate temporal variations in residence time. Both current (i.e., as of July 1999) and historical assignment data (i.e., as of September 1987, September 1990, September 1995, and June 1998), containing 1,973,214 records obtained from Headquarters Air Force Materiel Command (HQ AFMC), Wright-Patterson Air Force Base (WPAFB), Ohio was included in the analysis. Air Force personnel assigned to bases located in the pacific theatre of operations (PACAF) were also included in the analysis for the 1987, 1990, 1995, and 1999 assignment groups. A total of 369 spreadsheets containing 733 time-on-station distributions were prepared. Each spreadsheet derived from the 1987, 1990, 1995, and 1999 data also included age and grade distributions for the officer and enlisted personnel. Eighty-five (85) additional spreadsheets containing dependent age distributions were also prepared. They included all 65 stations in the 1998 data set, and the dependents at Dover AFB, Edwards AFB, Elmendorf AFB, Maxwell AFB, and Minot AFB from the 1987, 1990, 1995 and 1999 data sets.

Across all five data sets (1987, 1990, 1995, 1998, and 1999) the mean residence time on station was 915 days (2.51 years) for enlisted personnel and 692 days (1.90 years) for officers. The shortest time on station was one day for both officer and enlisted personnel. The maximum time on station was 11,322 days (31.02 years) for enlisted personnel and 9,861 days (27.02 years) for the officers. The 95th percentile residence time on station, calculated for the 1998 data, was 2870 days (7.86 years) for enlisted personnel and 1671 days (4.58 years) for officers. The mean residence time for enlisted and officer personnel are a factor of 3.59 and 4.74 less, respectively, than the default value of 9 years used by the U.S. Environmental Protection Agency (EPA). Similarly, the 95th percentile residence time for enlisted and officer personnel are a factor of 3.82 and 6.55 lower than the default value of 30 years that is used by the U.S. EPA. Mean human health risk estimates using a benzene inhalation exposure scenario in a Monte Carlo simulation, were found to be lower than the EPA mean risk estimates by factors of approximately 4 and 5 for enlisted and officer personnel, respectively.

INTRODUCTION

Background

The application of the probabilistic approach to risk assessments provides a significant improvement over single point estimates in evaluating exposures to hazardous substances in many instances. Application of this technique using site-specific data in risk calculations, along with the development of military-specific exposure factors to more accurately assess exposures to chemical substances at military facilities, are encompassed in a relatively new program within the Air Force called Enhanced Site-Specific Risk Assessment (ESSRA). During a recent study ("Military-Specific Exposure Factors (MSEF) Study", Lurker, *et al*, September 1998) human health risk estimates using a Monte Carlo analysis (Crystal Ball®) showed the highest sensitivity to the duration of exposure factor. Consequently, assignment data for United States Air Force (USAF) active duty military personnel located at installations in the continental United States (CONUS) were acquired from the Personnel Directorate at Headquarters Air Force Materiel Command (HQ AFMC/DPZD) (Buckman & Tolle, 1998). This assignment data was analyzed using commercial off-the-shelf (COTS) software to provide time-on-station (exposure duration) distributions for risk analysis using Monte Carlo simulations (Crystal Ball®, Version 4.0). A sample of the assignment data set for 1998 that was obtained in American Standard Code Information Interchange (ASCII) format for officer personnel is shown in Figure 1.

Figure 1. 1998 Assignment Data, Enlisted Personnel (ASCII Text)

NAME@	DAS	DEP	DEP1	DEP2	DEP3	DEP4	DEP5	DEP6	DEP7	STATION	LOCATION	DDI
MOBLEY STEVE	9502									MCCLELLAN AFB CA (MTC)	MCCLELLAN	1
NORMAN MICHA	9512									EGLIN AFB FL (MTC)	EGLIN	1
PAUL NATHAN	9805									LACKLAND AFB TX (AETC)	LACKLAND	1
HOLDERMAN	9411	01								PETERSON AFB CO (SPC)	CHEYENNE	1
BRANSKY RAND	9403	02	M97							CHARLESTON AFB SC (AMC)	CHARLESTO	1
PETERS GARY W	9603	04	M90	M93	F98					LAUGHLIN AFB TX (AETC)	LAUGHLIN	1

@ These are not the actual names of persons listed in the data set
DAS = Date Arrived Station (year and month); DEP = Number of Dependents
DEP1 through DEP6 = (dependent child, gender and year of birth); DEP7 = (unknown code)
Station = Base of Assignment; Location = Member's Duty Area; DDI = Privacy Act Code; AFB = Air Force Base

The original data obtained during the MSEF study contained information on the arrival date (i.e., date each member arrived on station) for their current tour, their station of assignment, location of assignment, the number of dependents and the dependent's age. Because this information was received late in the study only example station specific analyses were run. The approach used in the study involved extracting data sets from the ASCII files using a Microsoft (MS) Access query, generating an MS Excel spreadsheet, obtaining descriptive statistics, plotting a frequency distribution chart, curve matching a cumulative distribution with a continuous distribution, running a simulation to obtain mean risk estimates and recording the results. The two locations selected for analysis included Wright-Patterson AFB, OH, because estimates of related data had been obtained through interviews with base housing personnel; and Cannon AFB, NM, a combat

mission oriented installation. The data, as expected, indicated that military personnel were more mobile than their civilian counterparts, with a mean time on station between 3 to 5 years.

Current Effort

The purpose of this project is to develop time-on-station distributions for all 65 of the CONUS Air Force installations where active duty Air Force officer and enlisted personnel were assigned in 1998. It is based upon the analysis of the 1998 assignment data sets obtained from HQ AFMC/DPZD in June 1998. Dependent age distributions for each of the 65 CONUS installations were also included in the tasking, along with a statistical analysis of the data and "best fit" on the basis of the chi-square goodness of fit statistic, plus normal distribution curve fits using Crystal Ball® software. Probabilistic risk estimates using a sample benzene exposure scenario for selected installations were also included for comparison of results to risk estimates where standard U.S. Environmental Protection Agency (U.S. EPA) default exposure duration was used in lieu of the time-on-station distributions.

The 1998 assignment data provided a single point in time estimate of Air Force population mobility. A modification to the original tasking was added in September 1999 to include the analysis of eight additional data sets that were obtained from HQ AFMC/DPZD on 31 July 1999. These additional data sets included both officer and enlisted personnel that were assigned to CONUS and Pacific Air Force (PACAF) installations in 1987 (circa September 1987), 1990 (circa September 1990), 1995 (circa September 1995), and 1999 (circa July 1999). Time-on-station distributions for each of the installations contained in these data sets were developed, along with their respective summary statistics, "best fit" and normal distribution curves. Age and grade distributions for both officer and enlisted personnel were also added to the spreadsheets because this additional information was included in the 1987, 1990, 1995, and 1999 data sets. An analysis of the temporal effects of time-on-station distributions across the multi-year data sets (i.e., 1987, 1990, 1995, 1998 and 1999) at Dover AFB, Edwards AFB, Elmendorf AFB (except 1998 - CONUS only), Maxwell AFB, and Minot AFB was also performed for this study.

METHODS

Initial Screening of Input Data

The 1998 ASCII files containing assignment data for officer and enlisted personnel were analyzed using COTS software (MS Access® and MS Excel®). The ASCII files were first uploaded into an Access® database for the initial screening/data review process (see Figure 2 for a sample of the Enlisted data table). Total time on station was calculated from the date arrived station (DAS) using 23 June 1998 as the current date of reference. A sample of the resulting Enlisted Days on Station Table is shown in Figure 3. A series of queries were performed on the resulting Enlisted Days on Station and the Officer Days on Station data tables within the database to develop time-on-station data distributions for all 65 AFBs that were identified in the data sets. Because some of the records included in the data sets that were received from HQ AFMC contained "9999" codes in the DAS field (indicating personnel assigned in the training "pipeline") the initial queries were modified to exclude these records from the data distributions. Three additional records were also excluded because their DAS field entry (2070,0, and 1150) resulted in the computation of a negative time-on-station result. Through this screening process 1873 records (out of a total of 289,295 or 0.647 percent) were excluded from the time-on-station data distributions.

Figure 2. Enlisted Data Table Imported from ASCII Text File

ID	NAME	DAS	DAYS	DEP	DEP1	DEP2	DEP3	DEP4	DEP5	DEP6	DEP7	STATION	LOCATION
1	MORRI	9502										MCCLELLAN AFB	MCCLELLAN
2	NORTC	9512										EGLIN AFB FL (MT	EGLIN
3	POSTE	9805										LACKLAND AFB T	LACKLAND
4	HOLDE	9411		1								PETERSON AFB C	CHEYENNE M
5	BANKU	9805										DYESS AFB TX (A	DYESS
6	COOK	9410		1								MACDILL AFB FL (	MACDILL
7	RIDDLE	9804										SHEPPARD AFB T	SHEPPARD
8	LEIDNE	9801										HOLLOMAN AFB N	HOLLOMAN
9	GREEN	9801										FALCON AFB CO (	FALCON
10	MCKEE	9802										HILL AFB UT (MTC	HILL
11	BRAW	9403		2	M97							CHARLESTON AFI	CHARLESTOI
12	STOWI	9805										MT HOME AFB ID	MOUNT HOMI
13	BELL (	9006										KEESLER AFB MS	KEESLER
14	PETTY	9603		4	M90	M93	F98					LAUGHLIN AFB TX	LAUGHLIN
15	PAGE	8710		1								TINKER AFB OK (	TINKER
16	KETCH	9408		2	M93							HOLLOMAN AFB N	HOLLOMAN
17	MARTII	9608										EDWARDS AFB C.	SAN BERNAF
18	WHITE	9604										EGLIN AFB FL (MT	EGLIN

Figure 3. Sample 1998 Enlisted Assignment Data Table

ID	NAME	DAS	DASDATE	STATION	LOCATION	DAYS
131482	TEMPL	9999	3/1/107	LACKLAND AFB TX (AETC	LACKLAND	690796
132675	HARRIS	9999	3/1/107	LACKLAND AFB TX (AETC	LACKLAND	690796
133574	BOYD F	9999	3/1/107	LACKLAND AFB TX (AETC	LACKLAND	690796
58894	SAUND	7005	5/1/70	TINKER AFB OK (MTC)	TINKER	10288
169612	DAVIS	7109	9/1/71	BOLLING AFB DC (AFDW	BOLLING	9800
11842	DEITEM	7111	11/1/71	BOLLING AFB DC (AFDW	BOLLING	9739
47665	MOSEL	7112	12/1/71	BOLLING AFB DC (AFDW	BOLLING	9709
29997	SINE A	7202	2/1/72	BOLLING AFB DC (AFDW	BOLLING	9647
116786	SANDS	7202	2/1/72	HANSCOM AFB MA (MTC	HANSCOM	9647
75960	WOOD	7207	7/1/72	BOLLING AFB DC (AFDW	FT MYER	9496
56514	CROTT	7209	9/1/72	BOLLING AFB DC (AFDW	BOLLING	9434
71053	JAMES	7311	11/1/73	BOLLING AFB DC (AFDW	BOLLING	9008
38118	BELL D	7403	3/1/74	TRAVIS AFB CA (AMC)	TRAVIS	8888
89401	QUEEN	7406	6/1/74	BOLLING AFB DC (AFDW	BOLLING	8796
166577	HARRIS	7406	6/1/74	LACKLAND AFB TX (AETC	LACKLAND	8796
212707	SWANS	7407	7/1/74	BOLLING AFB DC (AFDW	BOLLING	8766
96856	BRUCE	7407	7/1/74	PETERSON AFB CO (SPC	PETERSON	8766
38651	SHEPE	7408	8/1/74	BOLLING AFB DC (AFDW	BOLLING	8735
78109	LITTLE	7408	8/1/74	BOLLING AFB DC (AFDW	BOLLING	8735

An additional set of queries was performed to identify officers and enlisted personnel who were both assigned to and located at each of the 65 bases contained in the 1998 data set. This additional set of queries was necessary because approximately 7 percent of the enlisted personnel and approximately 13.3 percent of the officer personnel who were assigned to the 65 CONUS bases were actually located at another facility. The percentage of officers or enlisted personnel who were assigned to a given base, but who were actually located at a separate facility ranged from about 2 percent of assignees (e.g., Offutt AFB) to over 78 percent of assignees (e.g., Bolling AFB). The resulting data tables, Enlisted on Station and Officer on Station, contained 210,575 and 52,960 records, respectively. Records of 15,747 enlisted and 8,090 officers in the 1998 data set with residences at a separate facility were excluded from further analysis.

Development of Time-on-Station Distributions

The data contained in the Enlisted on Station and Officer on Station data tables were subsequently queried to develop time-on-station distributions for each of the 65 CONUS bases contained in the 1998 data sets. These distributions were imported into MS Excel® spreadsheets for further analysis using both MS Excel® and Crystal Ball® software. Both summary statistics (mean, median, mode, standard deviation, etc.) and distribution type (i.e., lognormal, weibull, extreme value, etc.) were computed for each distribution. In many instances, the "best fit" distribution (e.g., gamma, beta, wiebull or extreme value) was not lognornally distributed, as

anticipated for this type of data. The summary statistics for officer and enlisted personnel for each of the 65 AFBs were imported into two separate spreadsheets for comparison to the summary statistics for the total officer and enlisted data sets. The data distributions for Dover AFB, Edwards AFB, Elmendorf AFB (except 1998), Maxwell AFB, and Minot AFB, both officer and enlisted personnel, were also used as input assumptions in Crystal Ball® simulations to perform probabilistic risk assessments of benzene exposure scenarios for inhalation, dermal contact, and drinking water consumption. Sample copies of these distributions and their low, high, mean, standard deviation and 95th percentile time-on-station values are shown in Appendix A.

Development of Dependent Age Distributions

A MS Access® make table query was performed by joining the Enlisted and Enlisted on Station tables to create a new table called Enlisted Dependents on Station. This table contained the dependent data (i.e., number of dependents [DEP], and gender/birth year [DEP1], [DEP2], ...[DEP6]) for all enlisted personnel both assigned to and located at each of the 65 Military Personnel Flight (MPF) stations in the 1998 data set. Data from the DEP7 field was excluded because it contained unknown codes (e.g., 01, 02, etc.) that did not translate into dependent age information. A second make table query was performed by joining the Officers and Officer on Station tables to create a new table called Officer Dependents on Station. This table contained the dependent data (i.e., number of dependents [DEP], and gender/birth year [DEP1], [DEP2], ...[DEP6]) for all officer personnel both assigned to and located at each of the 65 MPF stations in the 1998 data set.

A series of make table queries were performed to develop DEP1 through DEP6 tables containing the dependent data from the DEP1 through DEP6 fields, using the Officer Dependents on Station and Enlisted Dependents on Station tables. The DEP1 through DEP6 tables also contained the dependent's birth year (BYEAR) and calculated age using June 1998 as a reference point. These new tables were subsequently queried to extract dependent age distributions that were imported into MS Excel spreadsheets. "Best fit" and normal distribution curves were developed from these age distributions using the distribution gallery routine contained within the Crystal Ball® software (see Appendix A).

Inclusion of Additional Data Sets

Eight additional data sets containing Air Force enlisted and officer assignment information for 1987, 1990, 1995, and 1999 were also obtained to develop time-on-station, age, and grade distributions. Dependent age distributions were also prepared from each of the data sets for Dover AFB, Edwards AFB, Elmendorf AFB, Maxwell AFB, and Minot AFB.

Each of these data sets included 16 data fields containing the following information: (1) social security account number (SSAN), (2) date of birth (DOB, by year and month), (3) date assigned station (DAS, by year and month), (4) grade (E1 through E9, coded 31 through 39 for enlisted personnel, and O1 through O10, coded 1 through 10 for officer personnel), (5) number of dependents (DEP), (6 – 11) birth year for the first through sixth dependent child, DEP1 through DEP6, (12) the LOCATION of the assignee, (13) the STATION of assignment, (14) a separation

code (if applicable), (15) their Duty Air Force Specialty Code (DAFSC), and (16) a privacy act code (DDI). These data sets were received as ASCII text files with each of the fields described above separated by a delimiter (i.e., a pipe [|]). The file names and number of records in each file were as follows: enl8709 containing 417,678 records, enl9009 containing 361,791 records, enl9509 containing 300,406 records, enl9907 containing 268,983 records, off8709 containing 99,987 records, off9009 containing 92,586 records, off9509 containing 74,624 records, and off9907 containing 67,864 records.

Each of the data sets contained assignment information for all Air Force installations located within the CONUS, plus the PACAF installations located within the pacific theatre of operations. In addition, up to 29 two-letter code station identifiers were included in the data sets. Both officer and enlisted personnel who were assigned to these two-letter code stations were not included in the data analysis process because their location information indicated they were widely distributed across a relatively large number of facilities, including AFBs that were no longer active. A summary of the records in the two-letter MPF code stations is shown in Table 1.

In addition to the two-letter code assignees in each data set, several thousand additional records had to be rejected because they contained the code "9999" in the DOB (used to compute age) and/or the DAS fields. Because of the unusable nature of some of the data contained in each data set, nearly 30 percent of the 1987 records were rejected, over 25 percent of the 1990 records were rejected, and between 10 and 15 percent of the 1995 and 1999 records were rejected. A description of the data set analysis process that was used to evaluate the additional assignment data from 1987, 1990, 1995, and 1999 is provided in Appendix D. A summary of the records from the additional data sets that were available for analysis is provided in Appendix E.

Table 1. Two-Letter MPF Records in Additional Data Sets

2-Ltr MPF	Total in 1987 Data		Total in 1990 Data		Total in 1995 Data		Total in 1999 Data	
Code	Enlisted	Officer	Enlisted	Officer	Enlisted	Officer	Enlisted	Officer
AK	875	245	885	224	0	0	0	0
BH	4462	976	3634	779	2	0	1	0
BN	2878	462	2625	455	0	0	0	0
BX	2570	409	2250	397	0	0	0	0
CF	4606	923	4321	946	0	0	0	0
CH	4757	893	4047	840	278	23	2	0
CK	6012	342	3855	329	1	0	1	0
EM	3024	342	2856	338	0	0	0	0
FA	1	2	0	0	0	0	0	0
GB	5131	748	3949	569	0	0	0	0
GW	4034	815	3809	785	396	27	3	0
HV	4484	588	3623	479	0	0	0	0
KY	3365	529	2935	552	219	15	1	0
LQ	0	0	1	0	1	0	1	0
LS	3679	525	2967	517	0	0	0	0
LW	6909	639	4571	541	1	0	1	0
MD	3532	807	2913	642	1892	229	1	0
ME	4005	1849	2305	1708	0	0	0	0
MY	3357	329	2976	338	0	0	0	0
NV	4611	1395	3746	1227	4	0	1	0
OT	1	0	0	0	0	0	0	0
PJ	3471	457	1813	193	2	0	1	0
PS	3757	521	3203	466	23	1	5	0
S1	0	0	0	0	1	0	0	0
WP	1	0	1	0	1	0	1	0
WQ	1	0	1	0	1	0	1	0
WV	2213	1106	933	1283	0	0	0	0
WY	1	0	0	0	0	0	0	0
WZ	3303	528	2975	528	0	0	0	0
Grand Total	85040	15430	67194	14136	2822	295	20	0

RESULTS AND DISCUSSION

Using the data set analysis process described in Appendix D, 369 spreadsheets containing a total of 733 time-on-station distributions were prepared. Each spreadsheet prepared from the 1987, 1990, 1995, and 1999 data also contain age and grade distributions for the officer and enlisted personnel. Dependent age distributions were prepared for all stations in the 1998 data including five of the major commands (Air Mobility Command (AMC), Air Force Materiel Command (MTC), Air Force Space Command (SPC), Air Education and Training Command (AETC) and Air Combat Command (ACC)). Dependent age distributions were also prepared for Dover AFB, Edwards AFB, Elmendorf AFB, Maxwell AFB, and Minot AFB from the 1987, 1990, 1995 and 1999 data.

Summary Statistics

The results of the analysis of the 1998 assignment data produced the following summary statistics for Air Force enlisted and officer personnel, respectively:

	Enlisted	Officer
Minimum Days on Station	30	22
Maximum Days on Station	10,288 (28.17 yrs.)	9,488 (25.98 yrs.)
Average Days on Station	1,033.34 (2.83 yrs.)	746.13 (2.04 yrs.)
Standard Deviation	959.35 (2.63 yrs.)	539.31 (1.48 yrs.)
95th Percentile	2870 days (7.86 yrs.)	1671 days (4.58 yrs.)

Summary statistics (minimum, maximum, mean, standard deviation, and 95th percentile time-on-station) for enlisted and officer personnel for all CONUS and PACAF installations contained in the 1999 data set are shown in Table B-1 (see Appendix B).

Analysis of all data sets provided the following summary statistics, with the mean and standard deviation averaged across the five-year groups (i.e., 1987, 1990, 1995, 1998, and 1999) for Air Force enlisted and officer personnel assigned to CONUS and PACAF facilities:

	Enlisted	Officer
Minimum Days on Station	1	1
Maximum Days on Station	11,322 (31.02 yrs)	9,861 (27.02 yrs)
Average Days on Station	915 (2.51 yrs)	692 (1.90 yrs)
Standard Deviation	879 (2.41 yrs)	563 (1.54 yrs)

A separate analysis of the time on station data for PACAF installations, as expected, showed that both enlisted and officer personnel are significantly more mobile in PACAF, with average days on station of 642 (1.76 yrs) and 491 (1.35 yrs), respectively.

Although the maximum time on station increased when the additional data is compared to the 1998 data, the increase is attributable to the 1999 data for both officer and enlisted personnel. However, both the average days on station and their respective standard deviations from the

mean decreased when the additional data is compared to the 1998 data set. This result is consistent with the anticipated trend towards longer time on stations in recent years because of reduced defense budgets containing fewer dollars for permanent change of station (PCS) assignments. It is interesting to note that an analysis of the summary statistics for five bases across all year groups, except Elmendorf AFB in 1998 (not included in the data set), confirms this general trend for the enlisted personnel, but not for the officers. A more detailed discussion of this analysis is included in Section III (Temporal Analysis of Time on Station Distributions).

Analysis of Time-on-Station Distributions

Analysis of the 65 time-on-station distributions for both officer and enlisted personnel extracted from the 1998 assignment data provided some other noteworthy findings. For example, the relatively rapid turnover of personnel at two training installations (Lackland AFB and Sheppard AFB), along with a number of long-duration assignments, resulted in a set of time-on-station data with relatively long tails that best fit a normal distribution. However, nearly 80 percent of the time-on-station distributions developed from the 1998 assignment data best fit a gamma, weibull, or beta distribution. Among the 130 time-on-station distributions, forty-eight (48) best fit a gamma distribution, 28 best fit a weibull distribution, and 27 best fit a beta distribution (shown in Tables 2, 3, and 4, respectively).

Most of the other 27 distributions best fit either an extreme value or exponential distribution. As previously mentioned, only two of the 130 time-on-station distributions best fit a normal distribution (Lackland and Sheppard enlisted), and five best fit a lognormal distribution (Bolling and Dover enlisted, and Brooks, Robbins and USAF Academy officers). In addition, nearly all distributions were positively skewed by a very small number of near career-length and career-length assignments ranging from 12 years to more than 28 years on station. Across both the enlisted and officer time-on-station data (1998) there were 5,871 records out of a total of 287,425 records (approximately 2 percent) in this category (i.e., >12 years on station). For the additional data sets, there were 9,423 records out of a total of 1,334,837 available records (approximately 0.7 percent) with time on station > 12 years. Thirty-four (34) percent of these records were identified in the 1999 data set and most (over 97 percent) were for enlisted personnel.

Analysis of Dependent Age Distributions

Nearly all of the dependent age distributions were uniform ("best fit") using the Chi-squared goodness of fit test included with the Crystal Ball® software. The dependent age distributions for AMC, MTC, and SPC were also uniform ("best fit"). However, the "best fit" for AETC was triangular, and it was exponential for ACC. Dependent ages ranged from less than 1 year to over 67 years and the average age was between 9 and 10 years at most installations. Analysis of the additional data sets across five installations (Dover AFB, Edwards AFB, Elmendorf AFB, Maxwell AFB, and Minot AFB) provided dependent ages ranging from less than 1 year to more than 84 years, with an average age of 9.4 years. Across these five bases Minot AFB had the youngest dependents (average age of 8.8 years) and Maxwell AFB had the oldest dependents (average age of 10.4 years). With two exceptions, all of the dependent age distributions were uniform (best fit). The dependent age distributions for Elmendorf AFB in the 1990 and 1995 data sets best fit a triangular distribution.

Table 2. Best Fit Distribution Type - Gamma

BASE	GRADE	MIN	MAX	MEDIAN	MODE	N	LOCATION	SCALE	SHAPE
Altus	Officer	22	3552	569	326	413	7.04	344.12	1.88
Andrews	Enlisted	30	6696	1065	699	3993	28.65	960.08	1.31
Andrews	Officer	22	6109	722	357	1072	15.51	469.44	1.82
Barksdale	Enlisted	30	6817	881	668	4506	27.90	768.59	1.39
Beale	Officer	53	4191	691	357	338	12.19	419.16	1.80
Davis-Monthan	Enlisted	30	7578	881	334	4897	25.50	712.55	1.51
Edwards	Officer	22	3826	660	387	529	8.80	377.62	1.97
F.E. Warren	Enlisted	30	7912	791	303	2790	29.55	921.49	1.18
F.E. Warren	Officer	22	2274	691	357	579	182.58	418.60	1.56
Fairchild	Enlisted	61	6940	943	273	3103	56.43	928.94	1.20
Falcon	Enlisted	30	4990	699	456	1481	24.60	491.72	1.71
Grand Forks	Enlisted	30	7912	1004	1461	3019	27.60	772.25	1.49
Hanscom	Enlisted	30	9647	881	426	837	27.45	820.58	1.30
Hill	Enlisted	30	7700	760	334	3543	28.35	750.32	1.31
Hurlburt	Enlisted	30	8248	943	365	6066	27.75	885.70	1.28
Hurlburt	Officer	53	4040	722	357	1139	23.06	465.71	1.74
Kelly	Officer	53	3705	691	722	686	0.00	294.71	2.50
Kirtland	Enlisted	30	6270	699	365	2886	28.80	742.26	1.24
Langley	Enlisted	30	6787	852	699	6074	29.10	829.81	1.32
Langley	Officer	53	4375	691	691	1813	0.00	304.70	2.29
Laughlin	Enlisted	30	4686	668	1096	547	23.55	463.98	1.61
Los Angeles	Enlisted	61	6359	821	273	466	56.43	826.38	1.18
Los Angeles	Officer	22	3979	691	691	855	0.00	315.34	2.37
MacDill	Officer	53	3644	660	660	711	0.00	231.98	2.98
Malmstrom	Enlisted	30	8401	760	395	2974	29.55	907.69	1.16
Malmstrom	Officer	22	3217	630	357	533	1,733.46	1,256.30	0.90
McChord	Enlisted	30	8401	852	365	2974	29.55	887.70	1.29
McChord	Officer	22	2944	660	722	457	6.05	418.51	1.82
McGuire	Enlisted	30	8248	852	1369	3934	29.40	837.23	1.29
Minot	Enlisted	30	8401	760	334	3836	29.70	891.16	1.14
Moody	Enlisted	30	6970	699	487	3379	25.95	565.66	1.54
Moody	Officer	53	2183	538	387	427	0.00	230.43	2.61
Mt. Home	Enlisted	30	6390	699	730	3675	24.45	542.27	1.61
Offutt	Enlisted	30	7366	912	638	6364	28.95	880.35	1.31
Peterson	Enlisted	30	8766	821	730	2048	29.25	713.66	1.43
Randolph	Enlisted	30	6574	943	760	2536	28.35	782.51	1.43
Robins	Enlisted	30	6817	852	699	3508	25.65	677.21	1.58
Scott	Enlisted	30	6512	821	699	3708	27.90	737.80	1.44
Shaw	Enlisted	30	6848	791	334	4259	29.70	709.77	1.41
Tinker	Officer	53	3582	722	357	1075	10.87	403.63	1.92
Travis	Enlisted	30	8888	1034	1126	5882	29.25	906.10	1.36
Tyndall	Enlisted	30	6359	821	334	2825	26.25	708.88	1.45
Tyndall	Officer	22	4344	448	204	752	21.23	397.99	1.38
USAF Academy	Enlisted	30	5235	699	365	1190	28.05	632.00	1.38
Vance	Enlisted	30	3834	760	699	368	23.10	567.98	1.59
Vance	Officer	22	2487	357	83	689	20.90	361.62	1.25
Whiteman	Enlisted	30	6300	821	212	2697	27.90	695.62	1.39
Wright-Patterson	Enlisted	30	7305	958	730	2786	25.95	833.20	1.41

Table 3. Best Fit Distribution Type – Weibull

BASE	GRADE	MIN	MAX	MEDIAN	MODE	N	LOCATION	SCALE	SHAPE
AFDW (Pentagon)	Enlisted	30	6086	791	730	1455	28.74	1,078.44	1.12
Altus	Enlisted	30	6940	791	181	1654	29.02	1,008.15	1.13
Beale	Enlisted	30	7031	730	699	2772	28.87	982.21	1.09
Buckley	Enlisted	30	4291	668	699	650	25.20	796.99	1.23
Cannon	Enlisted	30	6390	821	334	3109	27.32	1,052.92	1.24
Charleston	Enlisted	30	7335	1034	821	3486	28.82	1,345.79	1.08
Charleston	Officer	53	3918	722	722	560	36.85	831.48	1.66
Columbus	Enlisted	30	5264	791	212	564	26.89	994.48	1.13
Davis-Monthan	Officer	22	2852	691	357	808	74.19	758.30	1.52
Dover	Officer	22	2518	706.5	357	368	1.21	850.77	1.64
Edwards	Enlisted	30	6665	821	334	3063	29.77	1,084.62	1.15
Ellsworth	Enlisted	30	6390	821	303	2590	28.63	1,074.68	1.09
Falcon	Officer	53	3664	599	357	722	47.32	702.89	1.36
Hill	Officer	22	2671	630	357	581	10.46	722.59	1.58
Keesler	Officer	53	6566	722	722	911	47.78	803.30	1.34
Kelly	Enlisted	30	5752	852	730	3224	27.70	1,064.40	1.25
Laughlin	Officer	53	1818	387	357	749	50.74	434.85	1.26
Little Rock	Enlisted	30	7792	1004	699	3579	30.36	1,346.59	1.07
Luke	Officer	22	5105	479	326	704	18.59	600.15	1.23
MacDill	Enlisted	61	5874	699	699	2743	60.91	912.72	1.17
Maxwell	Officer	22	5135	387	326	1463	19.05	670.02	1.31
McClellan	Enlisted	30	6178	912	365	1761	29.21	1,238.17	1.17
Patrick	Enlisted	30	6574	912	699	1189	24.82	1,178.66	1.22
Randolph	Officer	22	4436	569	357	1664	19.21	721.79	1.30
Seymour Johnson	Enlisted	30	6086	912	303	3764	29.86	1,127.98	1.15
Seymour Johnson	Officer	22	3309	660	357	527	11.40	741.62	1.50
Vandenberg	Enlisted	30	7121	730	122	2553	29.79	963.57	0.98
Whiteman	Officer	22	3644	660	357	301	0.18	794.14	1.64

Temporal Analysis of Time on Station Distributions

A temporal analysis of the time-on-station data obtained from the 1987, 1990, 1995, 1998 and 1999 data sets for Dover AFB, Edwards AFB, Elmendorf AFB (except 1998), Maxwell AFB and Minot AFB was performed to evaluate the differences in the mean time on station for both enlisted and officer personnel. Summary statistics for enlisted and officer personnel for the five data sets are shown in Table 5. Although the mean time on station was highest among the enlisted personnel for the 1990-year group, generally, the mean time on station increased by approximately 125 days (0.343 years) from 1987 through 1999. A similar analysis of the mean time on station for the officer personnel shows the same peak for the 1990 group. However, the mean time on station for officers decreased by approximately 35 days (0.096 years) from 1987 through 1999. Among the five bases, enlisted personnel assigned to Dover AFB had the highest mean time on station (approximately 1350 days, or 3.7 years), and officer personnel assigned to Maxwell AFB had the lowest mean time on station (approximately 539 days, or 1.48 years). Across all year groups for the five bases, enlisted personnel, on average, remained at their assigned duty stations about one year longer than officer personnel assigned to the same stations. For the total population, enlisted personnel, on average, remained at their assigned duty stations approximately 223 days, or 0.61 years longer than their officer counterparts.

Table 4. Best Fit Distribution Type – Beta

BASE	GRADE	MIN	MAX	MEDIAN	MODE	N	ALPHA	BETA	SCALE
AFDW (Pentagon)	Officer	22	5135	722	357	2973	1.97	23.25	10,372.70
Barksdale	Officer	22	4831	722	326	838	1.43	14.40	9,758.62
Columbus	Officer	22	1848	357	357	779	1.32	9.73	3,732.96
Dyess	Enlisted	30	6117	852	365	3962	1.17	12.03	12,356.34
Dyess	Officer	22	4709	691	722	721	1.53	17.26	9,512.18
Eglin	Enlisted	30	6543	912	334	6003	1.17	11.86	13,216.86
Eglin	Officer	22	3644	691	387	1250	2.15	19.68	7,360.88
Ellsworth	Officer	22	2487	691	722	354	1.69	7.16	3,817.55
Fort George Meade	Enlisted	30	6543	699	334	2079	1.23	16.64	13,216.86
Fort George Meade	Officer	53	3279	752	722	250	2.69	15.57	5,459.54
Holloman	Enlisted	30	6817	760	334	3629	1.29	17.76	13,770.34
Holloman	Officer	53	2518	691	691	421	2.21	10.01	3,814.77
Lackland	Officer	22	4770	752	387	1803	1.53	15.01	9,635.40
Luke	Enlisted	30	6604	760	546	4553	1.34	16.97	13,340.08
Maxwell	Enlisted	61	6270	821	699	1621	1.31	14.78	12,665.40
McConnel	Enlisted	30	6725	912	1522	2144	1.21	13.47	13,584.50
McConnel	Officer	53	2549	752	326	401	1.60	3.76	2,829.39
McGuire	Officer	22	2487	691	326	632	1.41	3.83	2,698.40
Minot	Officer	53	3279	706.5	722	646	1.78	8.30	4,295.49
Nellis	Enlisted	30	6696	791	365	5322	1.38	17.52	13,525.92
Offutt	Officer	22	5135	752	722	1573	1.89	21.00	10,372.70
Pope	Enlisted	30	6725	791	699	3841	1.18	13.63	13,584.50
Pope	Officer	53	2914	691	691	588	1.81	8.09	3,948.47
Scott	Officer	22	5105	722	357	1849	2.25	17.86	10,312.10
Sheppard	Officer	22	3370	538	722	753	1.94	15.65	5,644.75
Tinker	Enlisted	30	10288	973	334	5335	1.27	20.55	20,781.76
Vandenberg	Officer	22	4556	538	53	754	1.45	20.86	9,203.12

Table 5. Days on Station Summary Statistics

Enlisted	1987	1990	1995	1998	1999	Officers	1987	1990	1995	1998	1999
	Dover AFB						**Dover AFB**				
Low	1	1	1	30	1	Low	1	1	1	22	1
High	7397	7489	8462	8523	9861	High	5540	5936	4779	2518	2860
Mean	1146	1410	1325	1466	1398	Mean	854	870	645	762	620
Std Dev	1098	1290	1367	1450	1445	Std Dev	884	843	504	476	496
95th	3410	4090	4626	4809	4656	95th	2937	2435	1505	1603	1713
Best Fit	Gamma	Exp.	Weibull	Lognorm	Weibull	Best Fit	Exp.	Gamma	Beta	Weibull	Beta
	Edwards AFB						**Edwards AFB**				
Low	1	1	1	30	1	Low	1	1	1	22	1
High	6909	6574	5997	6665	7030	High	3683	3349	3379	3826	4199
Mean	769	982	945	1061	1025	Mean	801	751	705	753	661
Std Dev	652	814	846	897	906	Std Dev	517	526	559	534	545
95th	1959	2627	2869	2707	2617	95th	1592	1735	1880	1833	1642
Best Fit	Weibull	Weibull	Gamma	Weibull	Beta	Best Fit	Extreme	Extreme	Gamma	Gamma	Beta
	Elmendorf AFB						**Elmendorf AFB**				
Low	1	1	1	NA	1	Low	1	1	1	NA	1
High	4871	5967	7793	NA	9192	High	3349	3287	3318	NA	2678
Mean	778	1073	969	NA	941	Mean	675	760	670	NA	652
Std Dev	539	579	762	NA	770	Std Dev	469	579	516	NA	447
95th	1888	2680	2454	NA	2586	95th	1553	1894	1704	NA	1461
Best Fit	Weibull	Beta	Weibull		Beta	Best Fit	Gamma	Beta	Beta		Extreme
	Maxwell AFB						**Maxwell AFB**				
Low	1	1	1	61	1	Low	1	1	1	22	1
High	5662	6758	5783	6270	6635	High	5509	4779	4810	5135	5508
Mean	842	1039	937	1031	1033	Mean	462	513	450	637	633
Std Dev	722	872	826	838	893	Std Dev	568	601	530	476	523
95th	2253	2927	2638	2618	2738	95th	1543	1645	1461	1483	1491
Best Fit	Beta	Beta	Gamma	Beta	Beta	Best Fit	Extreme	Extreme	Exp.	Weibull	Exp.
	Minot AFB						**Minot AFB**				
Low	1	1	1	30	1	Low	1	1	1	53	1
High	6605	6910	8219	8401	9618	High	3440	3196	4048	3279	2952
Mean	852	1093	879	1046	1017	Mean	674	793	713	759	612
Std Dev	810	931	969	1014	1028	Std Dev	482	561	593	492	459
95th	2434	2877	3106	3088	2937	95th	1590	1863	1926	1583	1481
Best Fit	Gamma	Weibull	Exp.	Gamma	Exp.	Best Fit	Gamma	Beta	Exp.	Beta	Extreme
mean	877.4	1119	1011	920.8	1082.8	5 Bases	693.2	737.4	642.6	582.2	635.6
Mean	768.7	969.4	876.9	1033.3	928.9	Pop.	680.5	738.9	655.8	746.1	640.6
std. dev.	687.8	895.4	743	681.2	790.4	5 Bases	596.4	629.8	547.6	492.2	528.4
Std. Dev.	718.1	876.7	902.5	959.4	937.1	Pop.	543.2	588.6	589.7	539.3	553.8

Analysis of Age, Grade, and Number of Dependents

The assignment data obtained for the 1987, 1990, 1995 and 1999 groups included the date of birth and grade of the enlisted and officer personnel assigned to bases in the CONUS and PACAF. In additional, all data sets included the number of dependents enlisted and officer personnel had in their households at the time the data was obtained. A summary of the average age, grade, and number of dependents for both enlisted and officer personnel contained in the data sets is presented in Table 6. As shown in the table, the average grade and number of dependents for enlisted and officer personnel remained fairly constant from 1987 through 1999. The average grade for enlisted personnel was E4 (Senior Airmen) and the average grade for officers was O3 (Captain). The number of dependents for officers was consistently higher than for enlisted personnel (2.43 vs. 2.13); however, the number of dependents for enlisted personnel peaked in 1998 at 2.31, and generally increased from 1.97 in 1987 to 2.19 in 1999. The age for both enlisted and officer personnel increased between 1987 and 1999. The increase in the average age for enlisted personnel was nearly two years (from 27.64 years to 29.32 years). The increase in the average age for officers was less than 1.5 years.

Table 6. Average Age, Grade, and Number of Dependents

Year	Age		Grade		No. of Dependents	
	Enlisted	Officer	Enlisted	Officer	Enlisted	Officer
1987	27.64	34.08	E4	O3	1.97	2.46
1990	28.71	34.39	E4	O3	2.03	2.42
1995	29.06	35.1	E4	O3	2.16	2.42
1998	NA	NA	NA	NA	2.31	2.45
1999	29.32	35.45	E4	O3	2.19	2.43

NA - Data Not Available

Probabilistic Risk Estimates

Time-on-station distributions from the 1987, 1990, 1995, 1998, and 1999 data sets for both enlisted and officer personnel assigned to Cannon AFB, New Mexico, were used to estimate human health risk for sample benzene exposure scenarios. Standard EPA default exposure factors for body weight, respiratory/ventilation rates, skin surface area, and water intake rates were used in the risk estimate calculations. However, standard EPA default values for exposure duration were replaced by the time-on-station distributions to assess the effect on probabilistic risk estimates. By running Monte Carlo simulations using Crystal Ball® software, the risk calculations for the following exposure routes were performed: inhalation of indoor air, ingestion of drinking water, and dermal contact with soil. Unit concentrations of 1 mg/m^3, 1 mg/L, and 1

are commonly used to establish risk-based cleanup criteria for soil and water. Mean risk estimates derived from these simulations were compared to the mean risk estimates for the same scenarios where standard EPA default exposure duration factors were used instead of the time-on-station distributions. The run preferences selected for the Monte Carlo simulations are shown in Figure C-1, Appendix C. The probabilistic risk estimates obtained from the Monte Carlo simulations are summarized in Table C-1, Appendix C.

Inhalation of indoor air for the sample benzene exposure scenario using standard EPA default values for exposure duration resulted in a mean risk estimate of 7.36×10^{-4}. The mean risk estimate for the same scenario using the time-on-station distribution for enlisted personnel at Cannon AFB, New Mexico ranged from 1.64×10^{-4} (1987 data) to 2.33×10^{-4} (1998 data), a factor of 4.49 to 3.16 lower than the EPA estimate. Similar comparisons for the ingestion of drinking water and dermal contact with soil produced factors ranging from 4.69 to 3.39 lower risk, and 4.95 to 3.60 lower risk, respectively, for the enlisted personnel at Cannon AFB. Mean risk estimates for officer personnel assigned to Cannon AFB, compared to standard EPA estimates, were, on average, lower by factors of 5.21, 5.53, and 5.83 for the inhalation of indoor air, ingestion of drinking water, and dermal contact with soil exposure scenarios, respectively. Mean risk estimates for the officers are significantly lower than for the enlisted personnel because their mean time on station is about 30 percent lower. In all example risk estimate calculations, the lower risk estimates for Air Force personnel compared to risk estimates using standard EPA default exposure duration values is directly attributable to their lower exposure duration (i.e., time on station). The sensitivity of the mean risk estimate to the exposure duration is demonstrated in the Crystal Ball reports included in Appendix C.

Mean risk estimates for the sample benzene exposure scenarios were run by using the best fit of the time-on-station data to the distribution gallery provided within the Crystal Ball® software. Mean risk estimates were also calculated using the normal distribution fit from the Crystal Ball® gallery. Across all five year groups for the enlisted and officer personnel assigned to Cannon AFB, New Mexico, mean risk estimates using the normal distribution were higher than the mean risk estimates that were calculated using the best fit (see Table C-1, Appendix C). The difference in the mean risk estimates ranged from an increase of approximately 19 percent to more than 30 percent when the results using the best fit distribution were compared to the results using the normal distribution. Initially, an analysis of this result suggested that the difference in the mean risk estimate is directly proportional to the goodness of fit statistic. This analysis also suggested that the distribution that best fit a given set of data would always provide the lowest mean risk estimate, for a given set of data. However, further analysis indicates that mean risk estimates using the worst fitting distribution may be significantly lower than the mean risk calculated with the best fitting distribution. For example, the mean risk estimate for inhalation of indoor air using the sample benzene exposure scenario is 1.91×10^{-4} using the best fit of the time-on-station distribution (normal, chi-square = 3,337.98) for officers at the Pentagon in 1999. Using the worst fit of this distribution (Pareto, chi-square = 16,704.04) in the sample benzene exposure scenario produces a mean estimate of 7.35×10^{-5} for inhalation of indoor air risk. Among the 74 bases identified in the 1999 data set, the time-on-station distribution for enlisted personnel at Sheppard AFB, TX produced the highest chi-square value (24,667.49) for the best fit distribution (beta) in the Crystal Ball® gallery. Within this same data set, the time-on-station distribution for enlisted personnel assigned to Los Angeles AFB, CA produced the lowest chi-

square value (23.5) for the best fit distribution (weibull) in the Crystal Ball® gallery. When these distributions were used in the exposure duration assumption cell for the same scenario, the mean risk estimates were 1.22×10^{-4} and 2.28×10^{-4}, respectively (see Figure C-1 and the Crystal Ball reports shown in Appendix C). As expected, this result is more reflective of the mean time-on-station for these distributions (445 days and 985 days, respectively), rather than their goodness of fit statistic. Consequently, the goodness of fit statistic does not appear to be the best indicator of the distribution that should be used in the Crystal Ball® simulation to derive the mean risk estimate.

The time-on-station distributions developed from the Air Force assignment data contain values that can increase to relatively large numbers but cannot fall below zero. The time-on-station values are also positively skewed with most of them near the lower limit. Consequently, these distributions were expected to be lognormal in nature. However, as discussed in Section III above, most of the time-on-station distributions derived from the Air Force assignment data were not lognormal. Despite this unexpected result, additional Monte Carlo simulations were run for the benzene inhalation exposure scenario for both the enlisted and officer personnel assigned to Cannon AFB, New Mexico with the lognormal distribution selected from the Crystal Ball® gallery. The results of this additional analysis produced mean risk estimates for the enlisted personnel that were lower than the mean risk estimates calculated for the normal distribution. Mean risk estimates for the officer personnel were either equal to or lower than the mean risk estimates calculated for the best fit and the normal distributions.

CONCLUSIONS AND RECOMMENDATIONS

Population Mobility

The mobility of military personnel can be reasonably and readily evaluated by analyzing assignment data. Analysis of this data is relatively straight forward using COTS software. Other military population statistics, such as age, grade, and duty specialties can also be readily obtained from assignment data. As demonstrated in this study, military residence time distributions can be extracted from assignment data to support site-specific human health risk estimates at military facilities.

As anticipated at the outset of this study, an analysis of Air Force assignment data shows that the military population is significantly more mobile than the general U.S. population. On average, military (Air Force) personnel relocate every 2 to 3 years, which is significantly more frequent than the 9-year average used by the U.S. EPA to represent the general U.S. population. Moreover, the 95th percentile residence time (i.e., time on station) for military personnel is a factor of 4 or more lower than the 30-year residence time used by the U.S. EPA to calculate reasonable maximum exposure (RME) estimates in human health risk assessments.

Effect of Site-Specific Data on Probabilistic Risk Estimates

The effect of site-specific data on human health risk estimates was evaluated by substituting the time-on-station distribution for enlisted personnel assigned to Cannon AFB, New Mexico for the exposure duration distribution derived from general U.S. population statistics by the U.S. EPA in a series of Monte Carlo (Crystal Ball®) simulations. All other exposure factors used in the risk equation (e.g., body weight and respiration rates) to estimate human health risk for an inhalation of indoor air contaminated with benzene exposure scenario were unchanged. The results of the simulation runs, using 1,000 trials, produced mean risk estimates that ranged from 1.64×10^{-4} (1987 data) to 2.33×10^{-4} (1998 data). These estimates are a factor of 4.49 to 3.16 lower than the estimate (7.36×10^{-4}) obtained with the exposure duration distribution assumption used by the U.S. EPA. These significantly lower estimates of human health risk were anticipated based upon sensitivity analysis from Monte Carlo (Crystal Ball®) simulation runs, which show that exposure duration accounts for over 87 percent of the risk result.

Recommendations for Further Study

Some of the time-on-station distributions derived from the Air Force assignment data did not fit any of the 17 distributions included in the Crystal Ball® gallery very well, based upon the chi-square goodness of fit test. Although the fit routine provided with the Crystal Ball® software always produced a "best fit" of the time-on-station data to a distribution in the gallery, the relatively large chi-square values calculated for some of the distributions indicated that even the "best fit" was poor. This was particularly true for the time-on-station distributions at the major training centers, such as Keesler AFB, Lackland AFB, and Sheppard AFB. Probabilistic risk estimates derived from distributions that poorly fit the data may significantly over estimate or under estimate the true risk. Consequently, probabilistic risk estimates should be obtained using the most representative distribution for any given set of data. This distribution may not be either

the best fit or the worst fit within the Crystal Ball® gallery, based upon a goodness of fit statistic. A more rigorous analysis of the time-on-station distributions derived from the Air Force assignment data by a senior statistician is needed to adequately address this issue. Discussions with technical experts at the U.S. EPA are also needed to select the appropriate distribution for a given set of data when probabilistic risk estimation techniques are employed.

The military (Air Force) residence time distributions derived from the assignment data obtained from HQ AFMC provide a significant step forward in the development of military-specific exposure factors to support site-specific human health risk assessment at military facilities. Other military-specific exposure factors (i.e., body weight, body surface area, inhalation rates, and daily water intake) have also been identified (Lurker, *et al*) for use in estimating human health risk at military installations. However, much work remains to be done to fill the existing data gaps. Military-specific data on food consumption, activity patterns (e.g., time spent outdoors, time spent indoors, time spent gardening, swimming, showering, etc.), life expectancy, work habits (e.g., use of protective gear) and other occupational factors (e.g., military specialty) are also needed. Further review of technical publications available within the military community and additional contacts with interested parties is needed to identify/acquire this information.

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APPENDIX A

Air Force Officer and Enlisted Personnel
Time on Station Distributions, Summary Statistics,
And Dependent Age Distributions
For
Dover AFB, Edwards AFB, Elmendorf AFB,
Maxwell AFB, and Minot AFB
1999 Data

Figure A-1: Time on Station (Days) Distribution - July 1999
Dover AFB

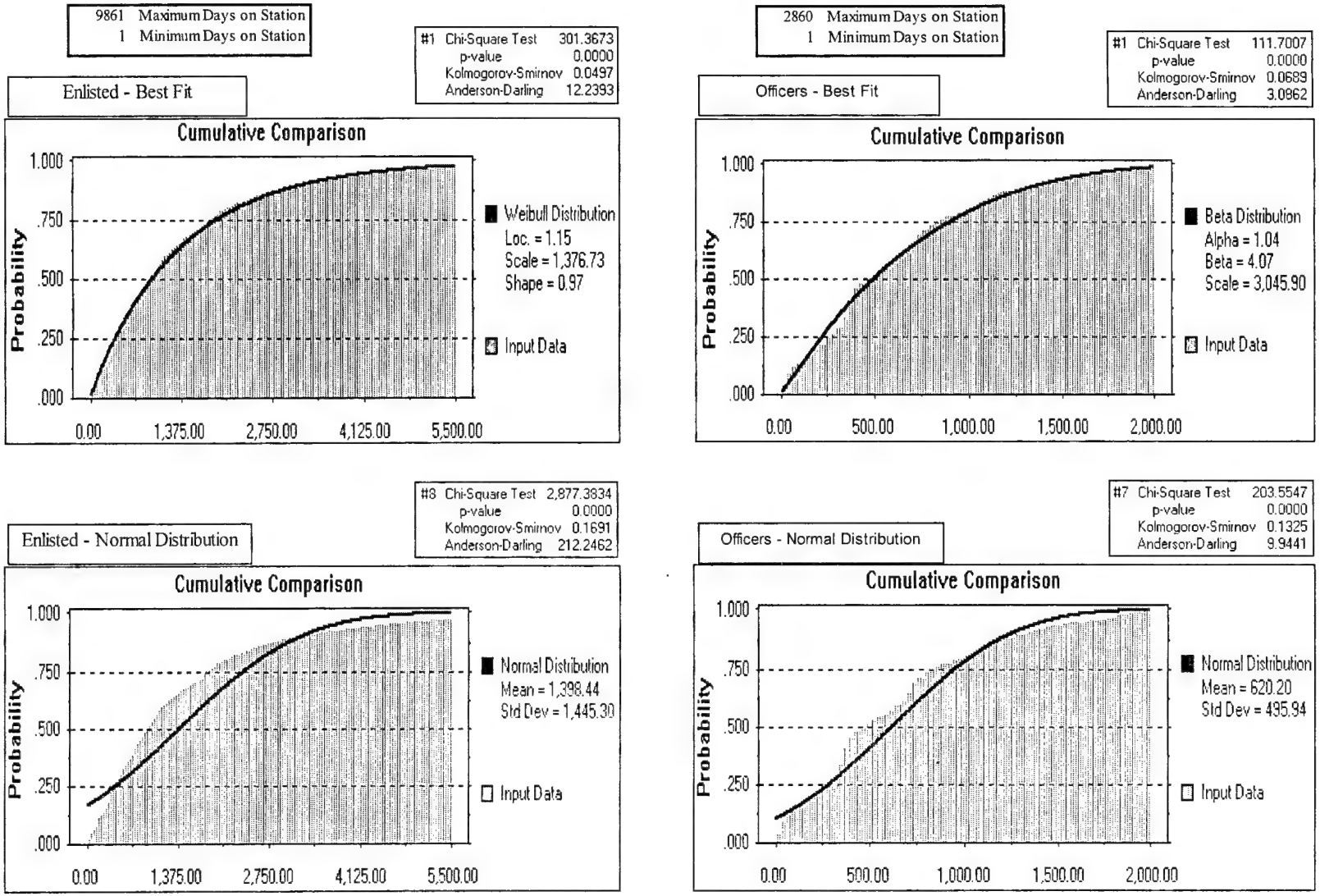


Figure A-2: Time on Station (Days) Distribution - July 1999
Edwards AFB

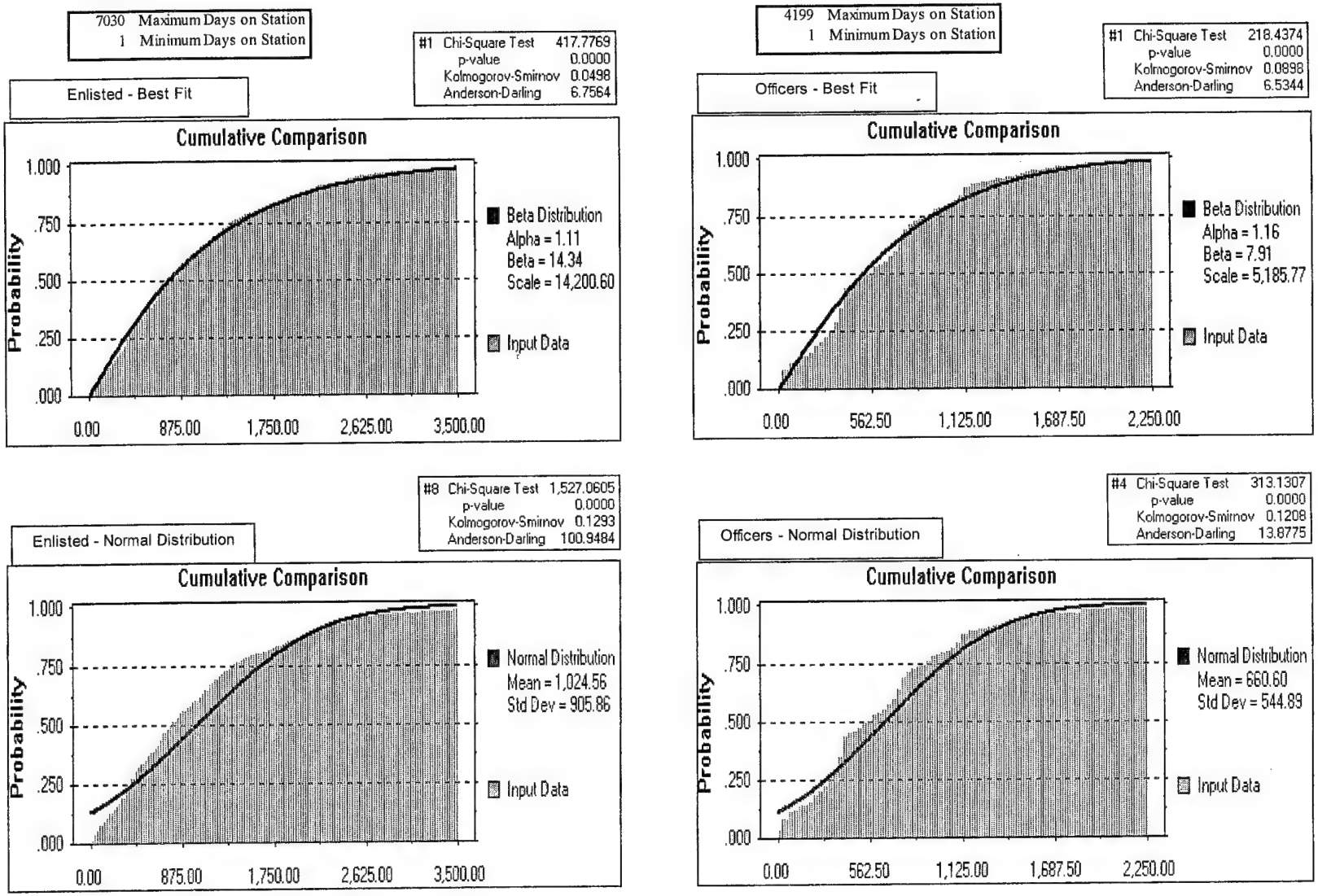
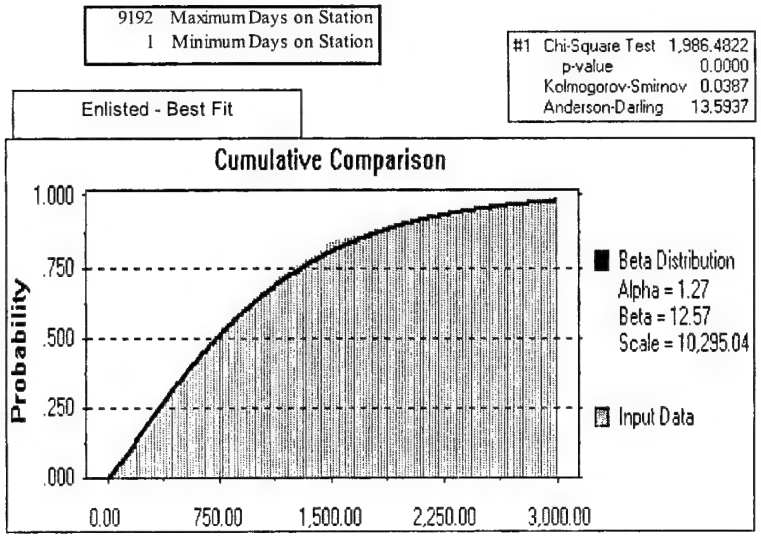
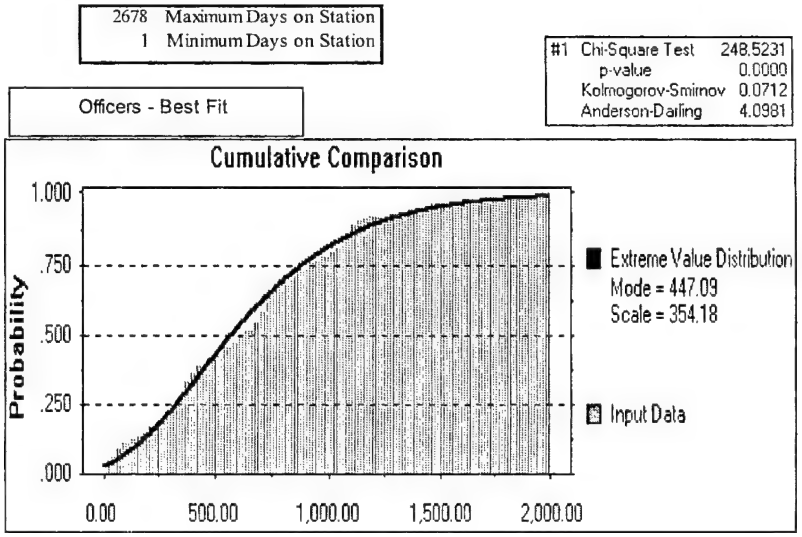
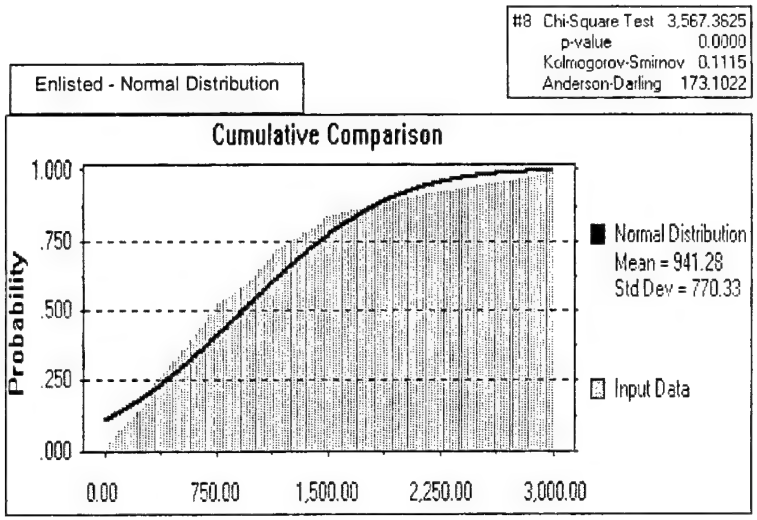


Figure A-3: Time on Station (Days) Distribution - July 1999
Elmendorf AFB







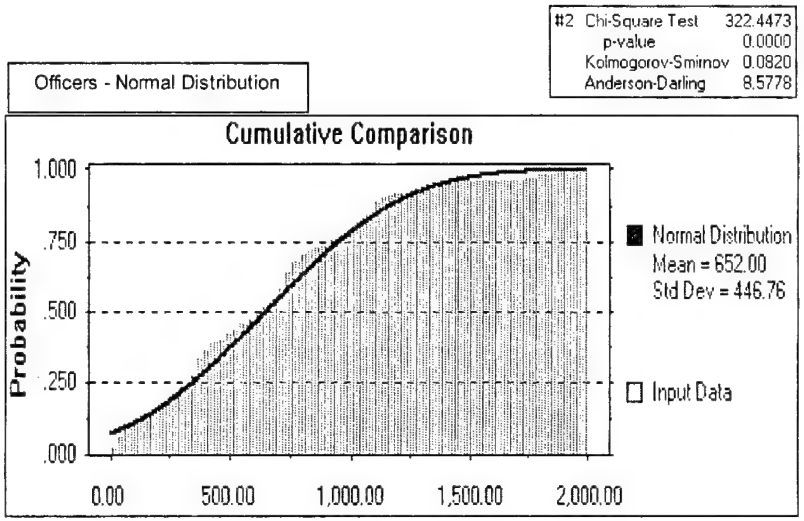
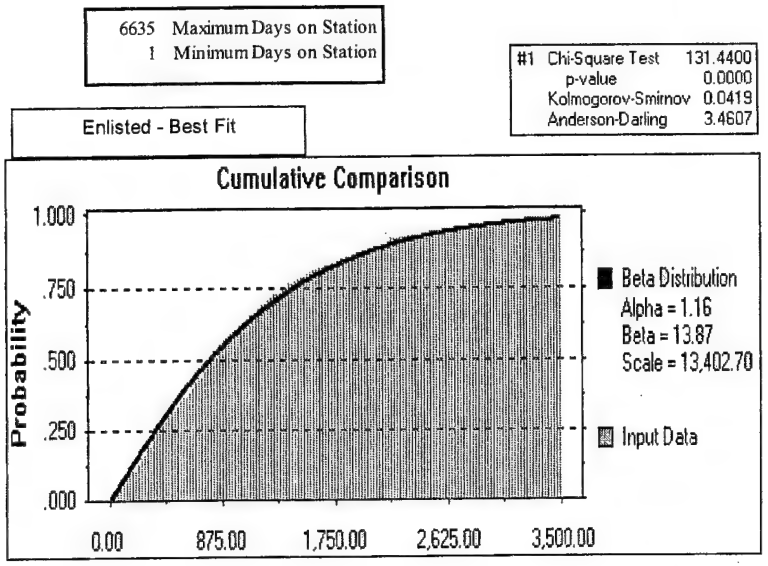
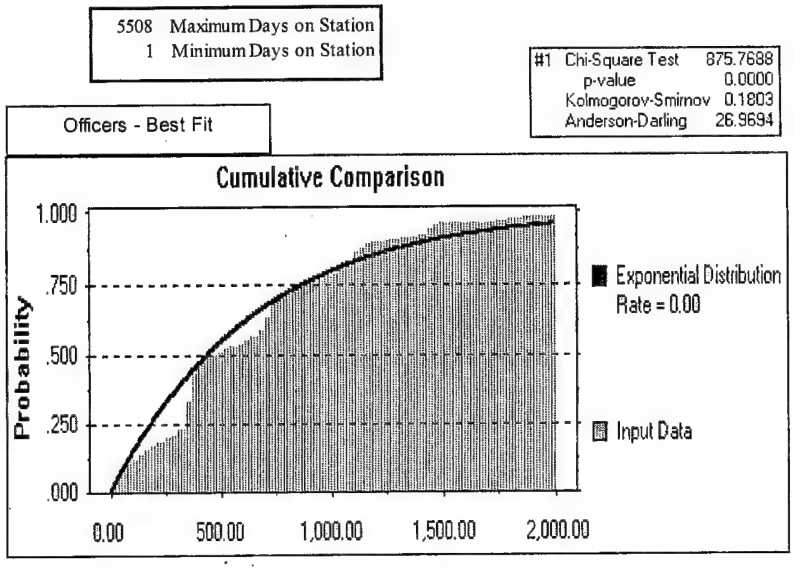
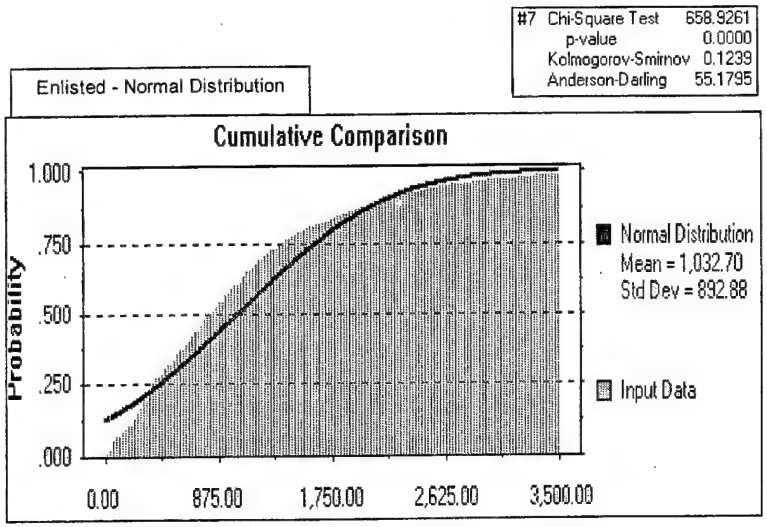


Figure A-4: Time on Station (Days) Distribution - July 1999
Maxwell AFB







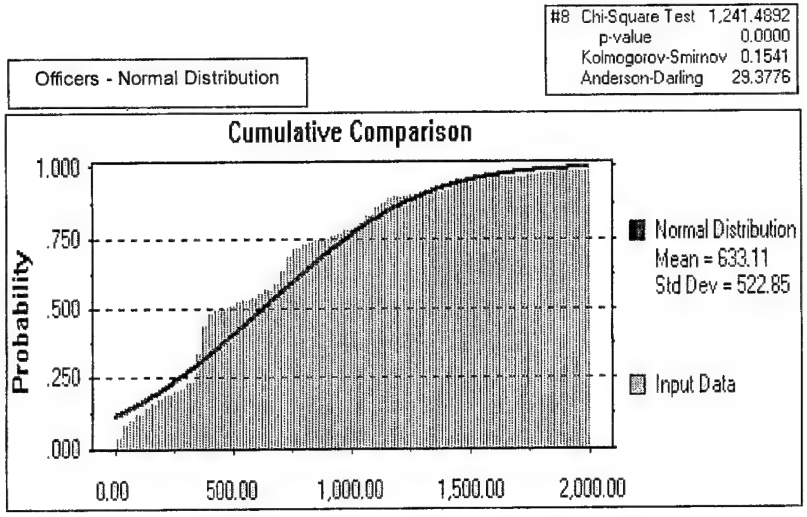
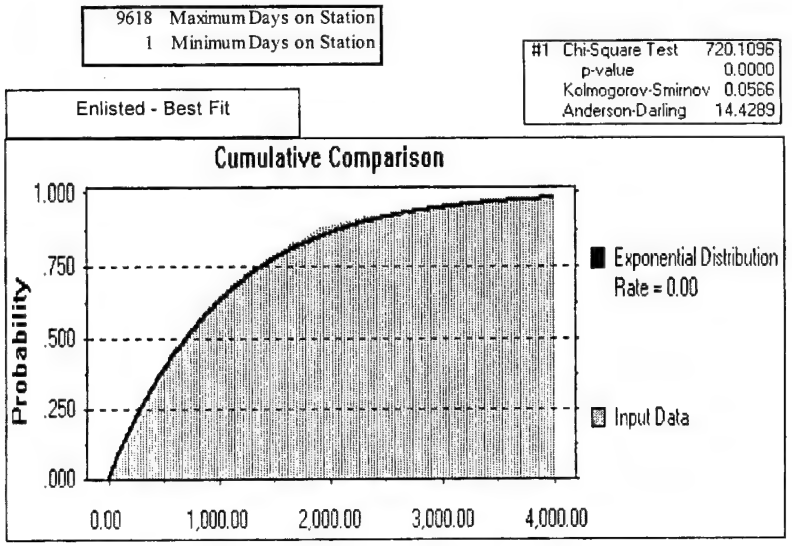
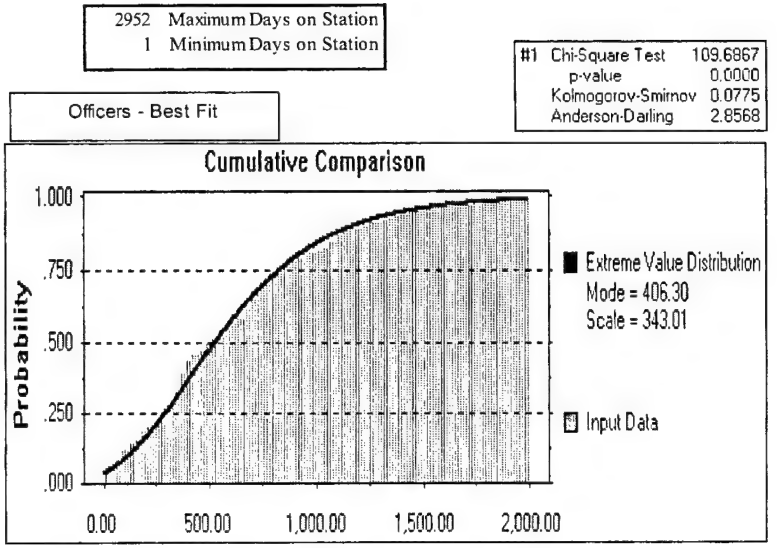
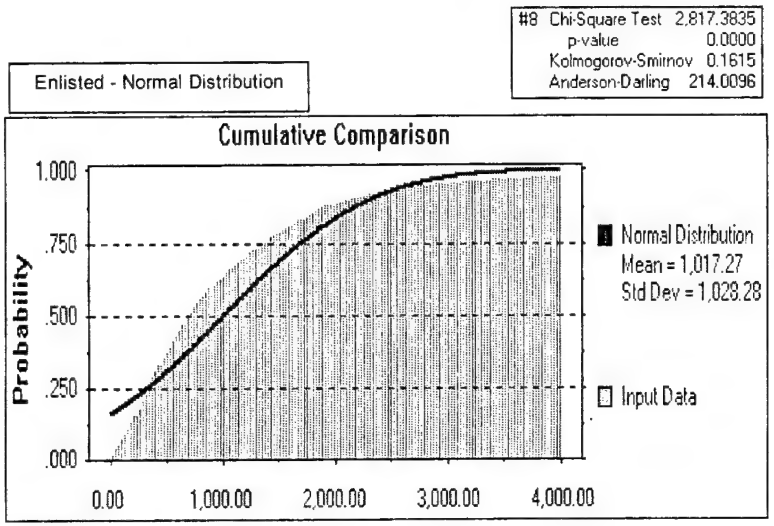


Figure A-5: Time on Station (Days) Distribution - July 1999
Minot AFB







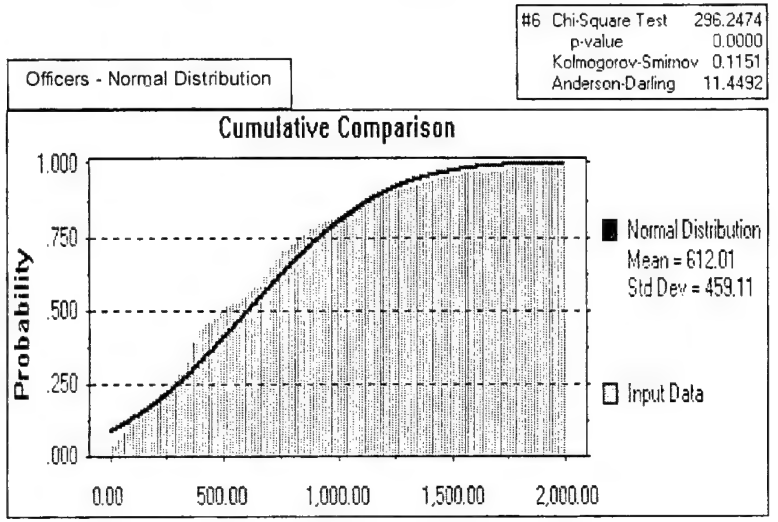
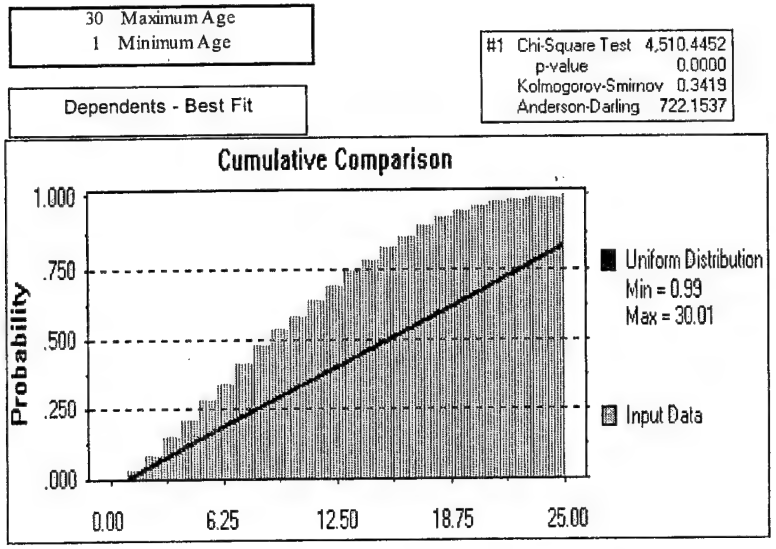
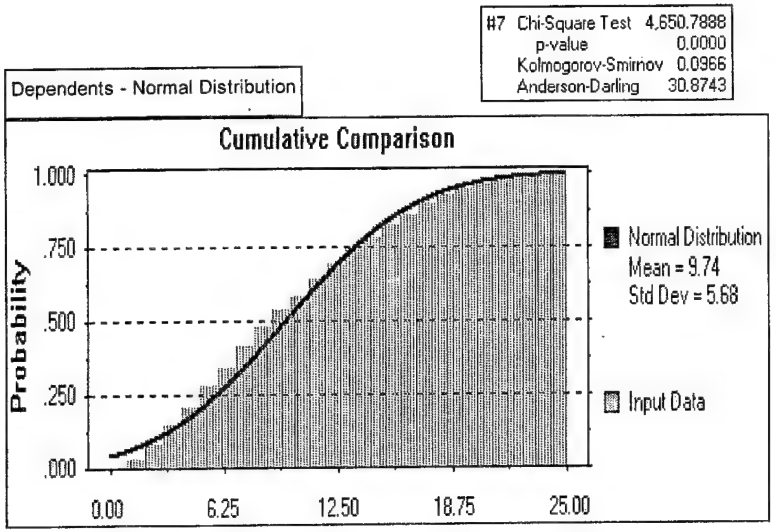


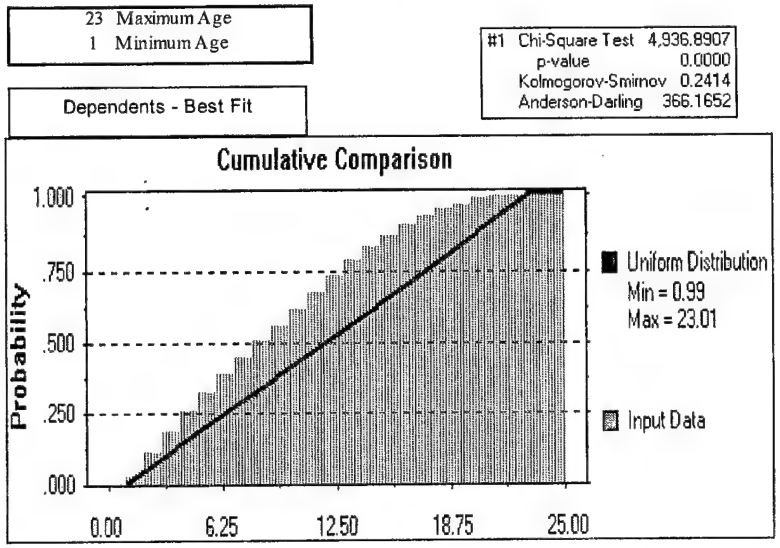
Figure A-6: Officers and Enlisted Dependents Age Distribution - July 1999

Dover AFB





Edwards AFB



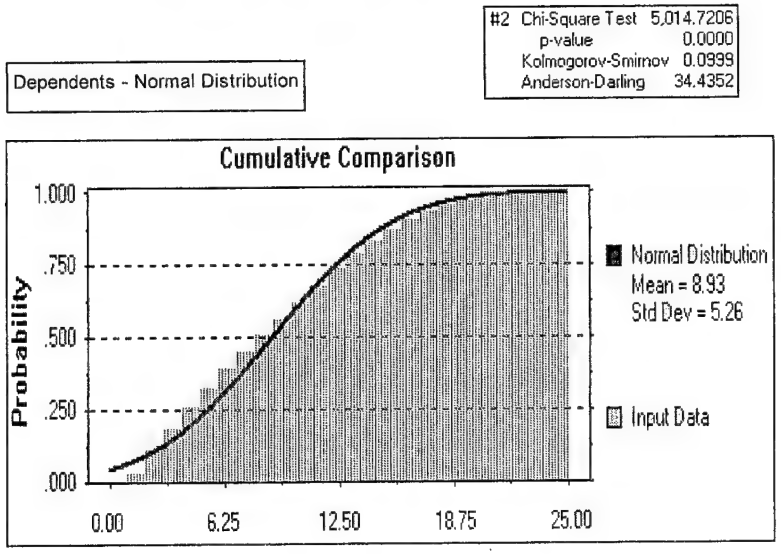
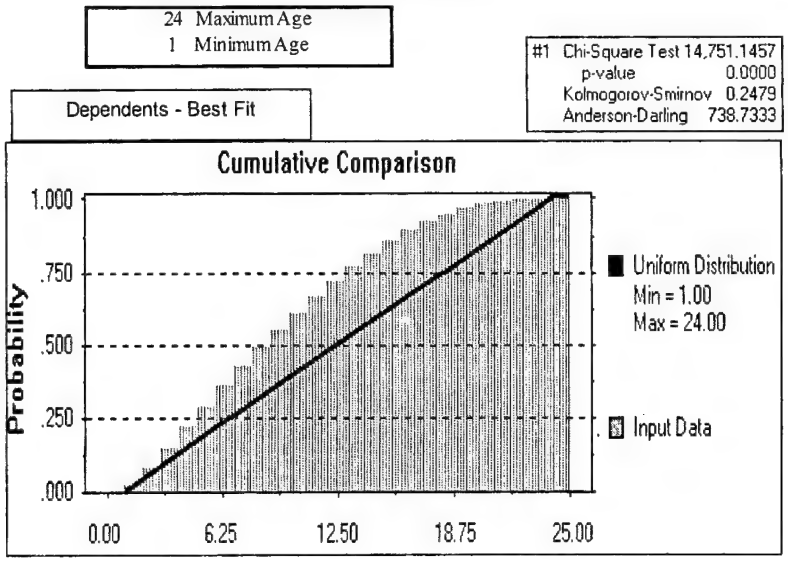
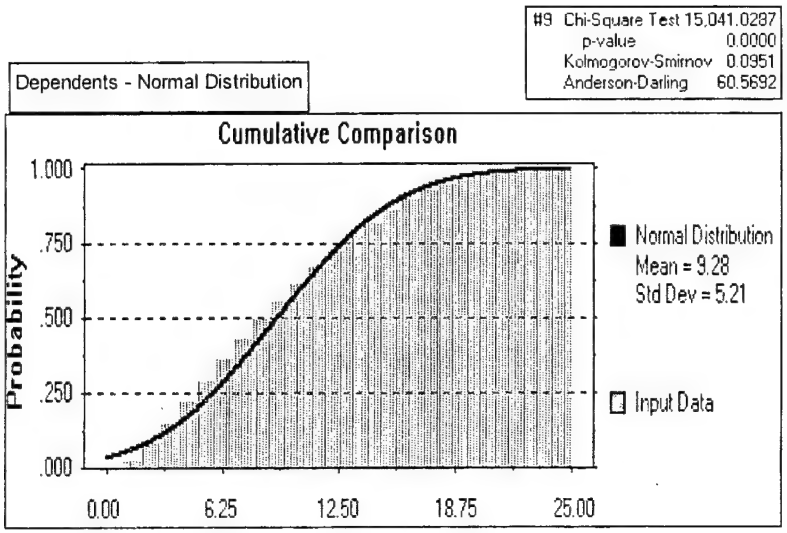


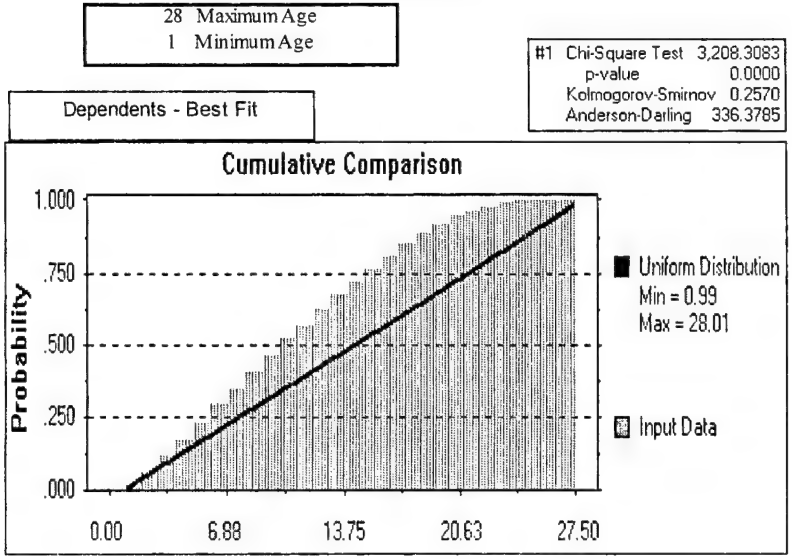
Figure A-7: Officers and Enlisted Dependents Age Distribution - July 1999

Elmendorf AFB





Maxwell AFB



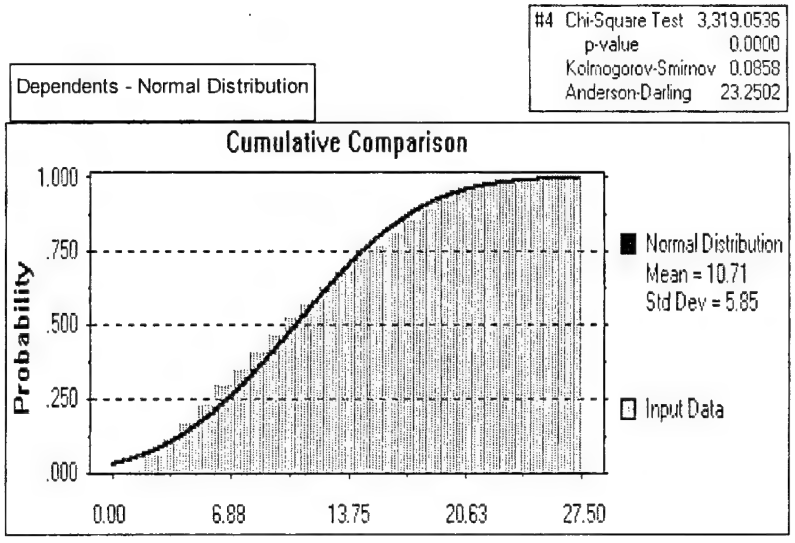


Figure A-8: Officers and Enlisted Dependents Age Distribution - July 1999

Minot AFB

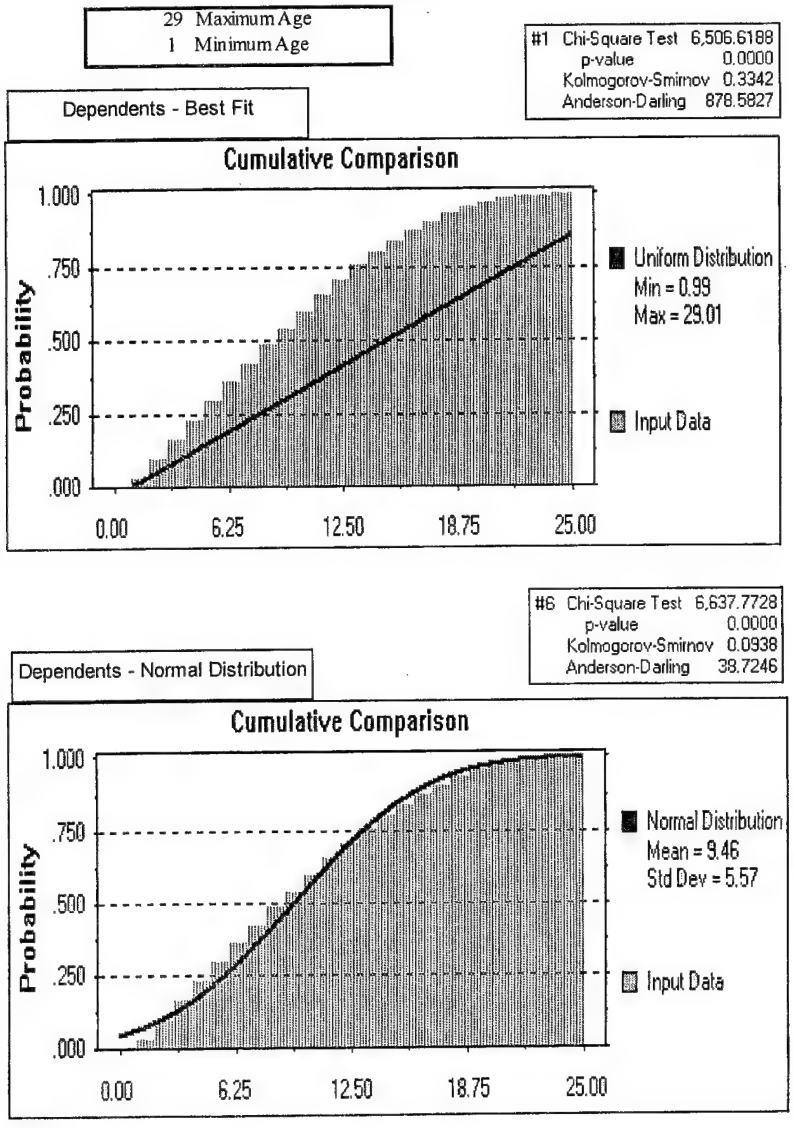


Table A-1: Dover AFB Summary Statistics

Dover Enlisted		Dover Officers	
Mean	1398.443	Mean	620.200
Standard Error	24.539	Standard Error	24.463
Median	911	Median	487
Mode	334	Mode	365
Standard Deviatio	1445.299	Standard Deviatio	495.940
Sample Variance	2088889.564	Sample Variance	245956.287
Kurtosis	4.232	Kurtosis	1.141
Skewness	1.974	Skewness	1.115
Range	9860	Range	2859
Minimum	1	Minimum	1
Maximum	9861	Maximum	2860
Sum	4851199	Sum	254902
Count	3469	Count	411

Table A-2: Edwards AFB Summary Statistics

Edwards Enlisted		Edwards Officers	
Mean	1024.562	Mean	660.599
Standard Error	16.605	Standard Error	23.213
Median	791	Median	546
Mode	365	Mode	395
Standard Deviatio	905.863	Standard Deviatio	544.891
Sample Variance	820587.250	Sample Variance	296906.710
Kurtosis	6.380	Kurtosis	6.686
Skewness	1.969	Skewness	1.913
Range	7029	Range	4198
Minimum	1	Minimum	1
Maximum	7030	Maximum	4199
Sum	3049097	Sum	363990
Count	2976	Count	551

Table A-3: Elmendorf AFB Summary Statistics

Elmendorf Enlisted		Elmendorf Officers	
Mean	941.275	Mean	651.999
Standard Error	9.966	Standard Error	15.369
Median	730	Median	638
Mode	334	Mode	730
Standard Deviatio	770.332	Standard Deviatio	446.763
Sample Variance	593411.658	Sample Variance	199597.568
Kurtosis	4.823	Kurtosis	1.277
Skewness	1.595	Skewness	0.919
Range	9191	Range	2677
Minimum	1	Minimum	1
Maximum	9192	Maximum	2678
Sum	5624120	Sum	550939
Count	5975	Count	845

Table A-4: Maxwell AFB Summary Statistics

Maxwell Enlisted		Maxwell Officers	
Mean	1032.705	Mean	633.107
Standard Error	21.981	Standard Error	15.651
Median	821	Median	456
Mode	334	Mode	334
Standard Deviatio	892.882	Standard Deviatio	522.849
Sample Variance	797238.619	Sample Variance	273371.276
Kurtosis	5.517	Kurtosis	11.238
Skewness	1.885	Skewness	2.164
Range	6634	Range	5507
Minimum	1	Minimum	1
Maximum	6635	Maximum	5508
Sum	1703963	Sum	706547
Count	1650	Count	1116

Table A-5: Minot AFB Summary Statistics

Minot Enlisted		Minot Officers	
Mean	1017.272	Mean	612.013
Standard Error	16.122	Standard Error	17.777
Median	699	Median	515
Mode	365	Mode	365
Standard Deviatio	1028.280	Standard Deviation	459.110
Sample Variance	1057359.304	Sample Variance	210782.326
Kurtosis	8.553	Kurtosis	1.492
Skewness	2.410	Skewness	1.086
Range	9617	Range	2951
Minimum	1	Minimum	1
Maximum	9618	Maximum	2952
Sum	4138261	Sum	408213
Count	4068	Count	667

Table A-6: Time on Station (Days) Summaries

		Dover AFB					Edwards AFB				
		1987	1990	1995	1998	1999	1987	1990	1995	1998	1999
Enlisted	Low	1	1	1	30	1	1	1	1	30	1
	High	7397	7489	8462	8523	9861	6909	6574	5997	6665	7030
	Mean	1146	1410	1325	1466	1398	769	982	945	1061	1025
	Std Dev	1098	1290	1367	1450	1445	652	814	846	897	906
	95th	3410	4090	4626	4809	4656	1959	2627	2869	2707	2617
Officers	Low	1	1	1	22	1	1	1	1	22	1
	High	5540	5936	4779	2518	2860	3683	3349	3379	3826	4199
	Mean	854	870	645	762	620	801	751	705	753	661
	Std Dev	884	843	504	476	496	517	526	559	534	545
	95th	2937	2435	1505	1603	1713	1592	1735	1880	1833	1642
Dep. Age	Low	1	1	1	0.5	1	1	3	1	0.5	1
	High	25	24	28	28.5	30	23	23	24	24.5	23
	Mean	9.1	9	9.2	9.5	9.7	9	10.2	8.7	9.1	8.9
	Std Dev	5.5	5.5	5.4	5.6	5.7	5.1	5	5.3	5.4	5.3
	95th	19	20	20	20	20	19	20	19	19	19

Table A-6: Time on Station (Days) Summaries (Cont.)

		Elmendorf AFB					Maxwell AFB				
		1987	1990	1995	1998	1999	1987	1990	1995	1998	1999
Enlisted	Low	1	1	1	NA	1	1	1	1	61	1
	High	4871	5967	7793	NA	9192	5662	6758	5783	6270	6635
	Mean	778	1073	969	NA	941	842	1039	937	1031	1033
	Std Dev	539	579	762	NA	770	722	872	826	838	893
	95th	1888	2680	2454	NA	2586	2253	2927	2638	2618	2738
Officers	Low	1	1	1	NA	1	1	1	1	22	1
	High	3349	3287	3318	NA	2678	5509	4779	4810	5135	5508
	Mean	675	760	670	NA	652	462	513	450	637	633
	Std Dev	469	579	516	NA	447	568	601	530	476	523
	95th	1553	1894	1704	NA	1461	1543	1645	1461	1483	1491
Dep. Age	Low	1	1	1	NA	1	1	1	1	0.5	1
	High	28	84	31	NA	24	24	25	27	28.5	28
	Mean	8.8	9.7	8.8	NA	9.3	10.6	11	10.1	9.4	10.7
	Std Dev	5.4	5.6	5.3	NA	5.2	5.5	5.5	5.4	5.5	5.8
	95th	19	20	19	NA	19	20.5	21	20	20	21.5

Table A-6: Time on Station (Days) Summaries (Cont.)

		Minot AFB				
		1987	1990	1995	1998	1999
Enlisted	Low	1	1	1	30	1
	High	6605	6910	8219	8401	9618
	Mean	852	1093	879	1046	1017
	Std Dev	810	931	969	1014	1028
	95th	2434	2877	3106	3088	2937
Officers	Low	1	1	1	53	1
	High	3440	3196	4048	3279	2952
	Mean	674	793	713	759	612
	Std Dev	482	561	593	492	459
	95th	1590	1863	1926	1583	1481
Dep. Age	Low	1	1	1	0.5	1
	High	24	24	27	27.5	29
	Mean	8.4	8.7	8.6	9	9.5
	Std Dev	5.3	5.4	5.4	5.6	5.6
	95th	18.6	19	19	19.6	20

APPENDIX B

Summary Statistics
Time on Station (Days)
Officers and Enlisted Personnel
1999

Table B-1. Time on Station Summaries

		AFDW	ALTUS	ANDRSN	ANDRWS	BARKS	BEALE	BOLLING	BROOKS	BUCKLY	CANNON	CHRLST	CLMBUS	D-M
Enlisted	Low	1	1	1	1	1	1	1	1	1	1	1	1	1
	High	6451	7305	3833	8551	7182	5905	10165	6574	3743	7427	7700	4898	7000
	Mean	1050	909	478	1255	1070	913	1189	1027	705	861	1280	785	1094
	Std Dev	906	659	408	1135	941	836	1535	1025	547	787	1210	726	956
	95th	2944	2453	1254	3560	2799	2556	4717	3074	1819	2494	3774	2160	2891
Officers	Low	1	1	1	1	1	1	1	1	1	1	1	1	1
	High	5447	3925	1461	6482	5204	4564	2464	5508	1611	2191	2830	2221	2891
	Mean	678	636	334	810	863	661	579	835	581	525	675	415	678
	Std Dev	563	509	245	733	742	608	465	835	364	369	512	339	504
	95th	1801	1727	750	2168	2494	1714	1482	2418	1241	1197	1594	1098	1734

		DOVER	DYESS	EDWDS	EGLIN	EIELSON	ELSWTH	ELMDRF	FAIRCHL	FE WRN	FT. G-M	GDFLW	GDFKS	HANSCM
Enlisted	Low	1	1	1	1	1	1	1	1	1	1	1	1	1
	High	9861	6178	7030	8065	5752	8916	9192	7305	8277	6908	6300	11322	6939
	Mean	1398	1049	1025	1132	869	1027	941	1176	1074	847	641	1083	1091
	Std Dev	1445	944	906	1024	726	970	770	1037	1090	802	726	1027	948
	95th	4656	2891	2617	3164	2504	2891	2586	3164	3348	2372	2007	2922	3021
Officers	Low	1	1	1	1	1	1	1	1	1	1	1	1	1
	High	2860	5082	4199	2952	2160	2556	2678	3743	2282	3652	2221	2617	4960
	Mean	620	686	661	656	545	638	652	807	633	692	287	745	710
	Std Dev	496	583	545	458	406	485	447	620	454	543	324	543	568
	95th	1693	1795	1642	1479	1246	1654	1461	1861	1492	1633	915	1758	1516

Table B-1. Time on Station Summaries (Cont.)

		HICKAM	HILL	HOLMN	HRBTF	KDENA	KESLER	KELLY	KRTLD	KUNSN	LCKLND	LNGLY	LUGHL	LTLRK
Enlisted	Low	1	1	1	1	1	1	1	1	1	1	1	1	1
	High	7517	8065	9404	7517	7608	11230	5782	6635	5660	9799	7152	4898	7851
	Mean	850	960	888	1116	768	655	963	965	222	762	1039	713	1234
	Std Dev	702	900	783	1008	589	871	833	878	218	928	973	586	1220
	95th	2129	2738	2372	3134	1895	2380	2533	2738	410	2525	3044	1748	3955
Officers	Low	1	1	1	1	1	1	1	1	1	1	1	1	1
	High	2525	3044	2556	4413	1826	6939	4078	6755	515	5143	4748	2191	4321
	Mean	552	574	585	769	524	714	649	710	167	799	607	428	723
	Std Dev	395	430	441	645	347	590	505	582	138	697	489	349	531
	95th	1217	1308	1375	2150	1148	1591	1506	1703	380	2191	1467	1117	1719

		LA	LUKE	MCDIL	MLSTM	MAXWL	MCHRD	MCLLN	MCCNL	MCGUR	MINOT	MISAW	MOODY	MTHME
Enlisted	Low	1	1	1	1	1	1	1	1	1	1	1	1	1
	High	4291	7639	8126	9799	6635	9496	7517	7090	10773	9618	3955	7335	6755
	Mean	985	954	929	1067	1033	1086	1152	1051	1111	1017	718	879	885
	Std Dev	812	831	767	1078	893	1051	973	923	1042	1028	540	746	741
	95th	2459	2413	2500	3164	2738	2983	3013	2632	2952	2937	1836	2413	2448
Officers	Low	1	1	1	1	1	1	1	1	1	1	1	1	1
	High	3682	5478	4017	3590	5508	3317	3590	2922	2464	2952	2191	2464	1552
	Mean	671	537	633	628	633	705	785	735	682	612	533	554	551
	Std Dev	475	464	467	454	523	569	460	579	524	459	345	402	369
	95th	1481	1338	1349	1448	1491	1782	1495	1851	1724	1481	1104	1198	1136

Table B-1. Time on Station Summaries (Cont.)

		NELLIS	OFFUTT	OSAN	PATRK	PTRSN	POPE	RNDLPH	ROBINS	SCHRVR	SCOTT	SEYJHN	SHAW	SHPRD
Enlisted	Low	1	1	1	1	1	1	1	1	1	1	1	1	1
	High	11048	7731	4898	6939	9131	10653	6939	7182	3986	6877	6451	6300	9343
	Mean	966	1141	257	933	1025	1040	1095	1038	741	1029	1047	960	445
	Std Dev	833	1067	293	853	954	968	942	938	625	948	977	893	679
	95th	2479	3271	668	2510	2662	2799	2860	2769	2028	2830	3111	2678	1907
Officers	Low	1	1	1	1	1	1	1	1	1	1	1	1	1
	High	3103	3986	2252	2830	5539	2191	4595	4168	4017	5478	2952	4686	2525
	Mean	604	755	251	658	674	578	582	652	642	692	600	580	573
	Std Dev	425	605	222	520	560	461	524	544	474	531	473	468	434
	95th	1369	1869	693	1645	1657	1526	1542	1491	1488	1522	1480	1430	1418

		TINKER	TRAVIS	TYNDL	USAFAC	VANCE	VNDBR	WHTMN	W-P	YKOTA				
Enlisted	Low	1	1	1	1	1	1	1	1	1				
	High	7335	10165	6239	11260	4108	7486	6665	7366	6969				
	Mean	1191	1228	977	776	842	925	949	1146	803				
	Std Dev	1052	1139	843	744	743	1009	800	1015	654				
	95th	3287	3393	2647	2184	2351	2799	2418	3115	2206				
Officers	Low	1	1	1	1	1	1	1	1	1				
	High	3560	5447	4717	9861	2586	4929	2191	6209	2586				
	Mean	672	747	507	634	409	480	655	767	552				
	Std Dev	533	660	453	899	375	475	498	649	389				
	95th	1693	1811	1396	2201	1196	1201	1611	1887	1167				

List of Abbreviations Used in Table B-1

AFDW	Air Force Department in Washington, D.C.
ALTUS	Altus Air Force Base
ANDRSN	Andersen Air Force Base
ANDRWS	Andrews Air Force Base
BARKS	Barksdale Air Force Base
BEALE	Beale Air Force Base
BOLLING	Bolling Air Force Base
BROOKS	Brooks Air Force Base
BUCKLY	Buckley Air Force Base
CANNON	Cannon Air Force Base
CHRLST	Charleston Air Force Base
CLMBUS	Colombus Air Force Base
D-M .	Davis Monthan Air Force Base
DOVER	Dover Air Force Base
DYESS	Dyess Air Force Base
EDWDS	Edwards Air Force Base
EGLIN	Eglin Air Force Base
EIELSON	Eielson Air Force Base
ELSWTH	Ellsworth Air Force Base
ELMDRF	Elmendorf Air Force Base
FAIRCHL	Fairchild Air Force Base
FE WRN	Francis E. Warren Air Force Base
FT. G-M	Fort George Meade
GDFLW	Goodfellow Air Force Base
GDFKS	Grand Forks Air Force Base
HANSCM	Hanscom Air Force Base
HICKAM	Hickam Air Force Base
HILL	Hill Air Force Base
HOLMN	Holloman Air Force Base
HRBTF	Hurlburt Field
KDENA	Kadena Air Force Base
KESLER	Keesler Air Force Base
KELLY	Kelly Air Force Base
KRTLD	Kirtland Air Force Base
KUNSN	Kunsan Air Force Base
LCKLND	Lackland Air Force Base
LNGLY	Langley Air Force Base
LUGHL	Laughlin Air Force Base
LTLRK	Little Rock Air Force Base
LA	Los Angles Air Force Base
LUKE	Luke Air Force Base
MCDIL	MacDill Air Force Base
MLSTM	Malmstrom Air Force Base
MAXWL	Maxwell Air Force Base
MCHRD	McChord Air Force Base
MCLLN	McClellan Air Force Base
MCCNL	McConnell Air Force Base
MCGUR	McGuire Air Force Base
MINOT	Minot Air Force Base
MISAW	Misawa Air Force Base
MOODY	Moody Air Force Base
MTHME	Mt. Home Air Force Base
NELLIS	Nellis Air Force Base
OFFUTT	Offutt Air Force Base
OSAN	Osan Air Force Base
PATRK	Patrick Air Force Base
PTRSN	Peterson Air Force Base
POPE	Pope Air Force Base
RNDLPH	Randolph Air Force Base
ROBINS	Robins Air Force Base
SCHRVR	Schriever Air Force Base
SCOTT	Scott Air Force Base
SEYJHN	Seymour Johnson Air Force Base
SHAW	Shaw Air Force Base
SHPRD	Sheppard Air Force Base
TINKER	Tinker Air Force Base
TRAVIS	Travis Air Force Base
TYNDL	Tyndall Air Force Base
USAFAC	USAF Academy
VANCE	Vance Air Force Base
VNDBR	Vandenberg Air Force Base
WHTMN	Whiteman Air Force Base
W-P	Wright-Patterson Air Force Base
YKOTA	Yokota Air Force Base

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APPENDIX C

Probabilistic Risk Estimates – Cannon AFB, NM
Mean Risk Estimates for Benzene Exposure Scenarios
For 1987, 1990, 1995, 1998, and 1999
Time-on-station Distributions

Frequency Chart for:
Dermal Contact With Soil

Crystal Ball Reports
Inhalation of Indoor Air Risk (Cannon AFB Enl)
Groundwater Ingestion Risk (Cannon AFB Enl)
Dermal Contact With Soil Risk (Cannon AFB Enl)
Benzene Inhal. Risk-Sheppard Enl. (worst fit)
Benzene Inhal. Risk-Los Angeles Enl. (best fit)

Figure C-1: Crystal Ball Run Preferences

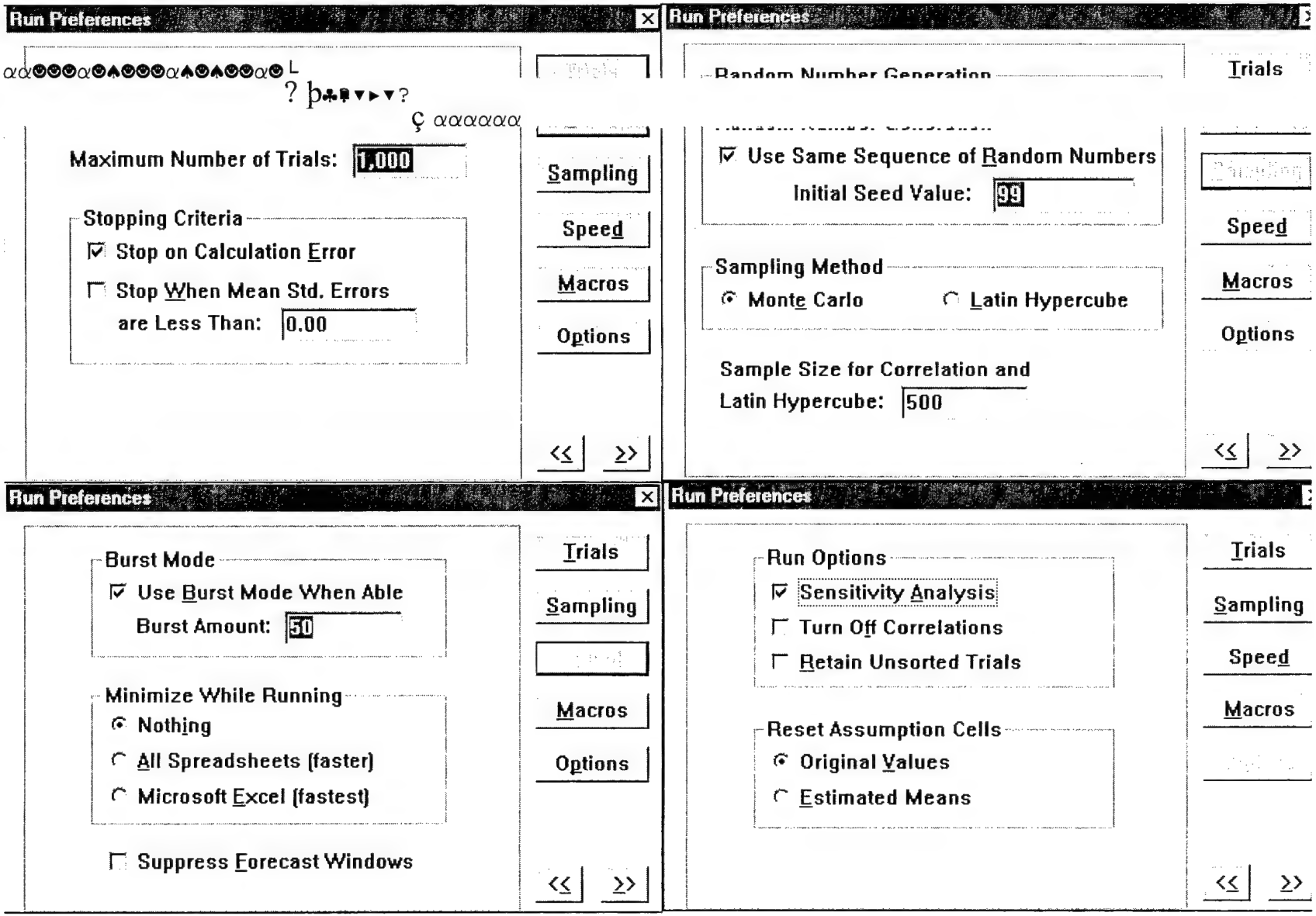
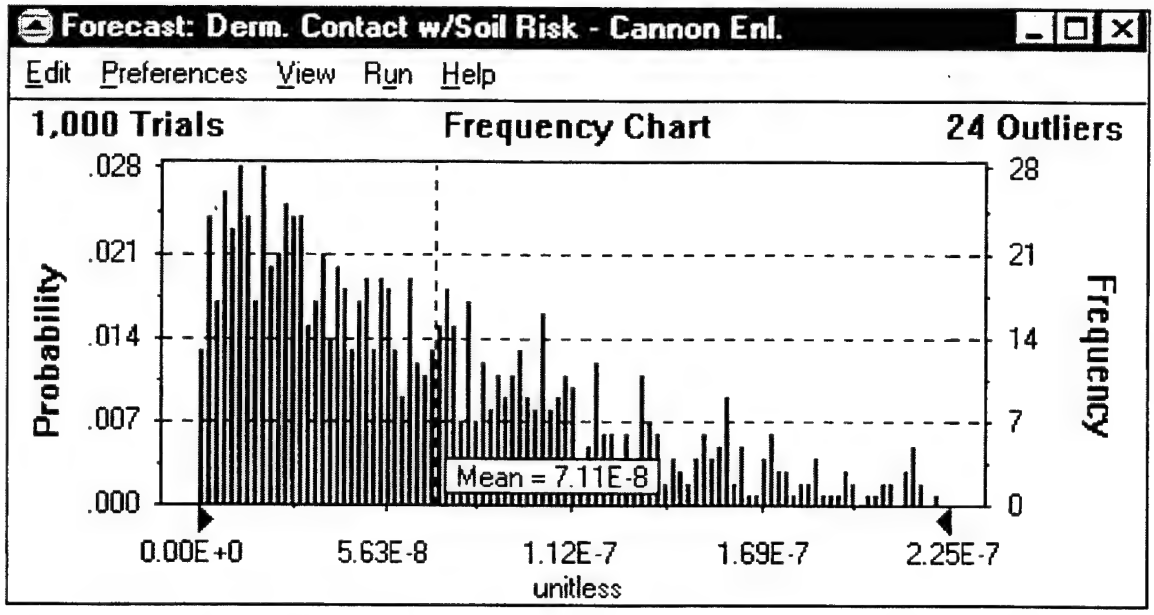


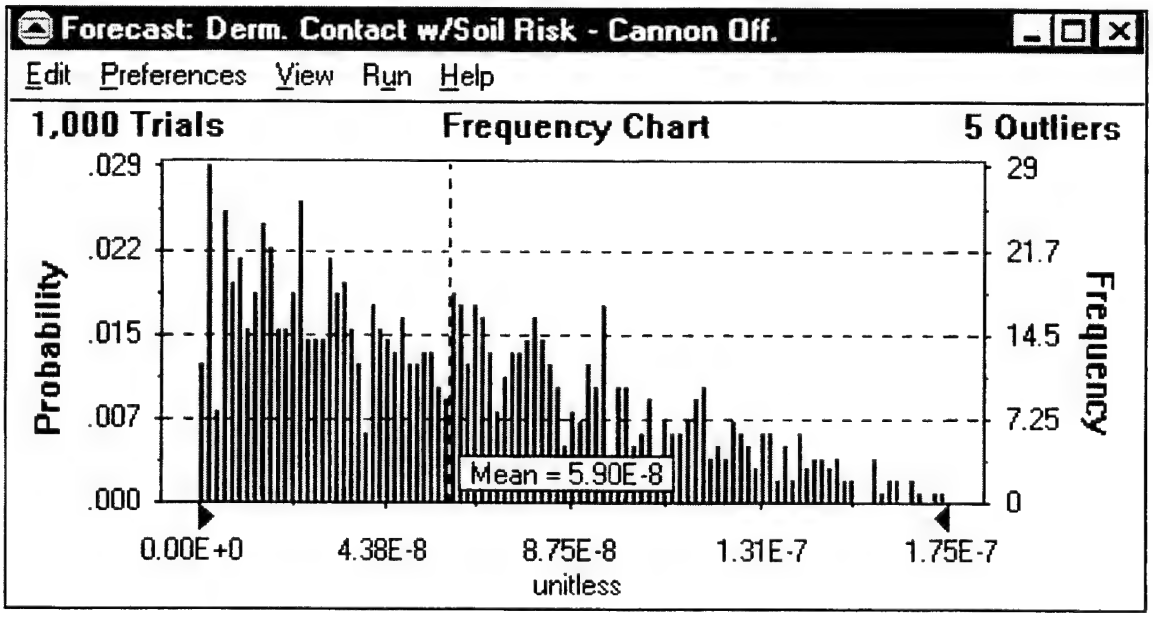
Table C-1
Probabilistic Risk Estimates, Cannon AFB, NM

		Exposure Duration (time on station - days)				Mean Risk Estimates - Benzene Exposure Scenario					
		NOS	Minimum	Maximum	Mean	Std. Dev.	IoIA-Best	IoIA-Norm	GwI-Best	GwI-Norm	DCS-Best	DCS-Norm
1987	Enlisted	3556	1	4567	729	578	1.64E-04	2.01E-04	1.54E-05	1.85E-05	7.11E-08	8.50E-08
	Officer	418	1	2038	593	412	1.39E-04	1.55E-04	1.28E-05	1.43E-05	5.90E-08	6.61E-08
1990	Enlisted	3744	1	4748	805	749	2.00E-04	2.44E-04	1.84E-05	2.21E-05	8.48E-08	1.01E-07
	Officer	463	1	2222	566	452	1.16E-04	1.57E-04	1.08E-05	1.43E-05	5.07E-08	6.60E-08
1995	Enlisted	4568	1	6452	846	719	1.93E-04	2.44E-04	1.78E-05	2.23E-05	8.16E-08	1.02E-07
	Officer	477	1	3591	751	522	1.73E-04	1.96E-04	1.61E-05	1.81E-05	7.32E-08	8.37E-08
1998	Enlisted	3109	30	6390	1010	800	2.33E-04	2.82E-04	2.13E-05	2.60E-05	9.77E-08	1.17E-07
	Officer	354	53	2822	675	410	1.57E-04	1.72E-04	1.44E-05	1.59E-05	6.71E-08	7.34E-08
1999	Enlisted	2893	1	7427	861	787	1.99E-04	2.59E-04	1.81E-05	2.35E-05	8.29E-08	1.07E-07
	Officer	297	1	2191	525	369	1.22E-04	1.38E-04	1.12E-05	1.27E-05	5.20E-08	5.88E-08
EPA Risk Estimate with Standard Default Exposure Factors							7.36E-04		7.22E-05		3.52E-07	

IoIA - Inhalation of Indoor Air
GwI - Groundwater Ingestion
DCS - Dermal Contact with Soil
Best - Best Fit w/in Crystal Ball Distribution Gallery
Norm - Normal Distribution Fit w/in Crystal Ball Distribution Gallery
NOS - Number of Personnel Assigned on Station

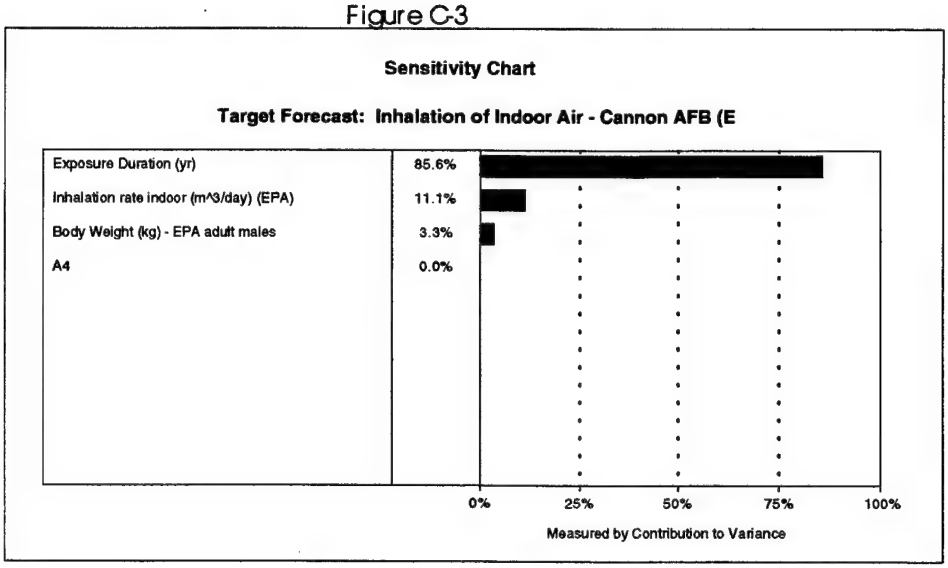
Figure C-2
Dermal Contact With Soil Risk, Benzene Exposure Scenario
Using Standard EPA Default Exposure Factors
Except with Time-on-Station Distribution for
Cannon AFB Enlisted and Officer Personnel, 1987





Crystal Ball Report
Simulation started on 10/7/99 at 11:37:03
Simulation stopped on 10/7/99 at 11:37:21

Figure C-3

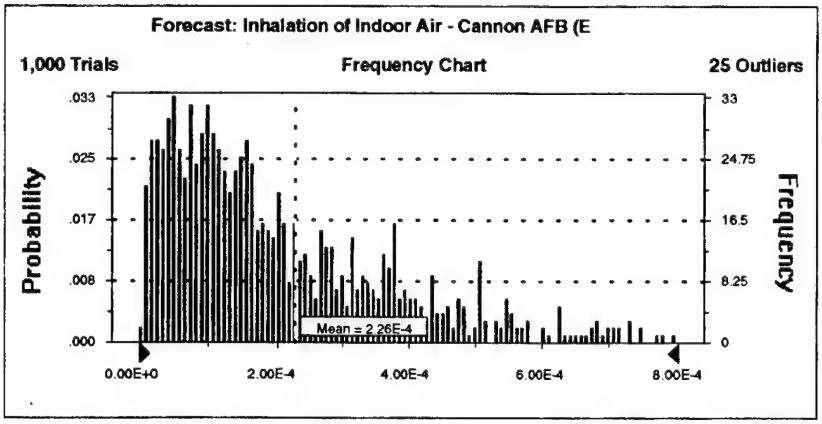


Forecast: Inhalation of Indoor Air - Cannon AFB (E **Cell: C23**

Summary:

Display Range is from 0.00E+0 to 8.00E-4
Entire Range is from 3.65E-6 to 1.77E-3
After 1,000 Trials, the Std. Error of the Mean is 6.72E-6

Statistics:	Value
Trials	1000
Mean	2.26E-04
Median	1.59E-04
Mode	---
Standard Deviation	2.12E-04
Variance	4.51E-08
Skewness	2.20E+00
Kurtosis	1.04E+01
Coeff. of Variability	9.38E-01
Range Minimum	3.65E-06
Range Maximum	1.77E-03
Range Width	1.76E-03
Mean Std. Error	6.72E-06



Forecast: Inhalation of Indoor Air - Cannon AFB (E (cont'd) **Cell: C23**

Percentiles:

Percentile	Value
0.0%	3.65E-06
2.5%	1.64E-05
5.0%	2.33E-05
50.0%	1.59E-04
95.0%	6.32E-04
97.5%	7.99E-04
100.0%	1.77E-03

End of Forecast

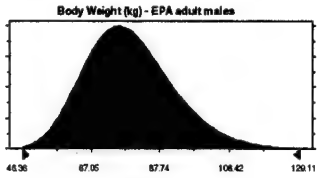
Assumptions

Assumption: Body Weight (kg) - EPA adult males **(inhal-epa.XLS)Sheet1 - Cell: C8**

Lognormal distribution with parameters:

Mean	78.50
Standard Dev.	13.50

Selected range is from 0.00 to +Infinity
Mean value in simulation was 78.21

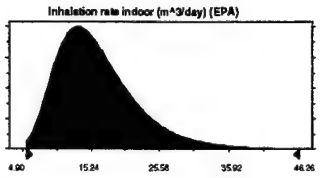


Assumption: Inhalation rate indoor (m^3/day) (EPA) **(inhal-epa.XLS)Sheet1 - Cell: C11**

Lognormal distribution with parameters:

Mean	16.15
Standard Dev.	6.26

Selected range is from 5.40 to 64.95
Mean value in simulation was 16.15

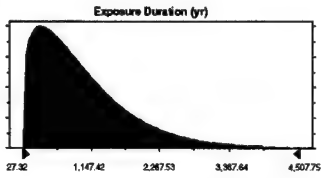


Assumption: Exposure Duration (yr) **(inhal-epa.XLS)Sheet1 - Cell: C9**

Weibull distribution with parameters:

Location	27.32
Scale	1,052.92
Shape	1.236289091

Selected range is from 27.32 to 6,390.00
Mean value in simulation was 994.10

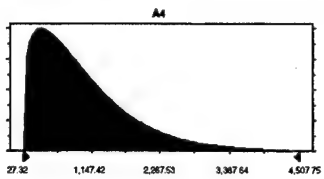


Assumption: A4 **(CANNON.XLS)Sheet1 - Cell: A4**

Weibull distribution with parameters:

Location	27.32
Scale	1,052.92
Shape	1.236289091

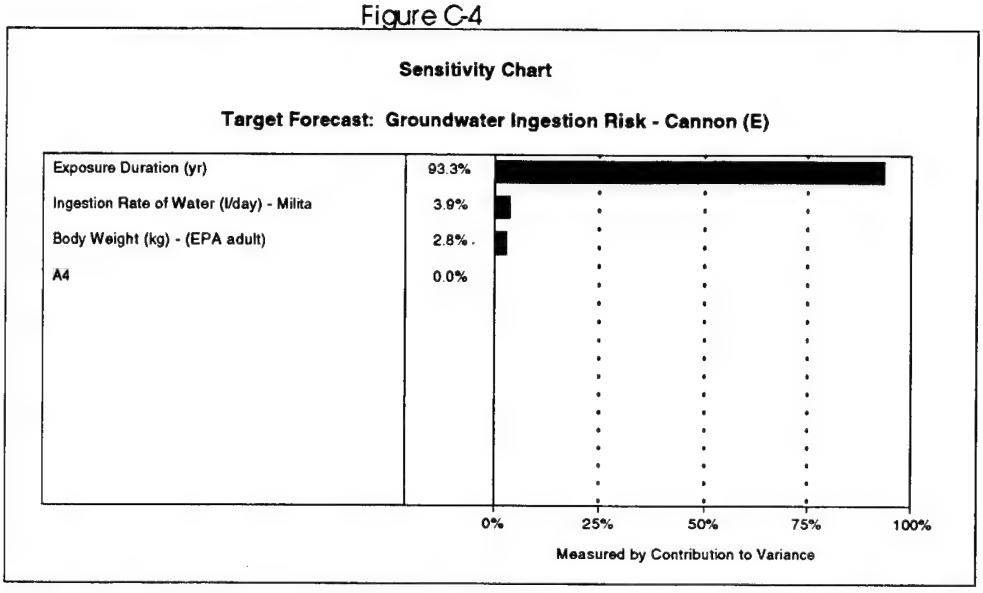
Selected range is from 27.32 to 6,390.00
Mean value in simulation was 1,013.13



End of Assumptions

Crystal Ball Report
Simulation started on 10/7/99 at 11:42:25
Simulation stopped on 10/7/99 at 11:42:43

Figure C-4

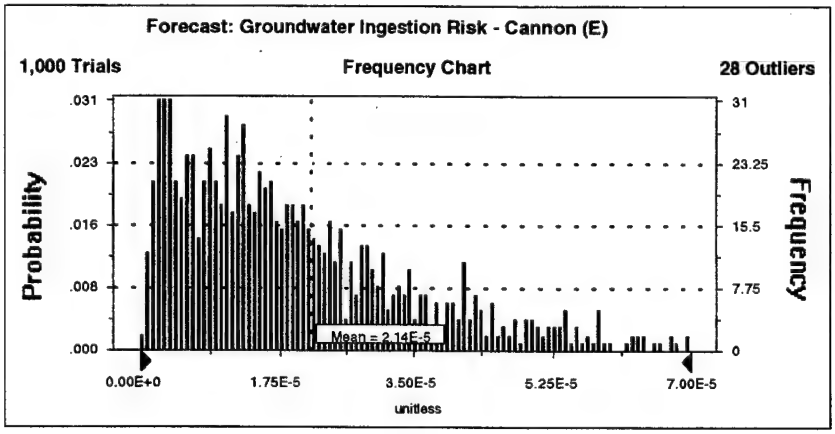


Forecast: Groundwater Ingestion Risk - Cannon (E) **Cell: C23**

Summary:

Display Range is from 0.00E+0 to 7.00E-5 unitless
Entire Range is from 3.64E-7 to 1.13E-4 unitless
After 1,000 Trials, the Std. Error of the Mean is 5.75E-7

Statistics:	Value
Trials	1000
Mean	2.14E-05
Median	1.64E-05
Mode	---
Standard Deviation	1.82E-05
Variance	3.31E-10
Skewness	1.62E+00
Kurtosis	6.19E+00
Coeff. of Variability	8.51E-01
Range Minimum	3.64E-07
Range Maximum	1.13E-04
Range Width	1.13E-04
Mean Std. Error	5.75E-07



Forecast: Groundwater Ingestion Risk - Cannon (E) (cont'd) **Cell: C23**

Percentiles:

Percentile	unitless
0.0%	3.64E-07
2.5%	1.78E-06
5.0%	2.37E-06
50.0%	1.64E-05
95.0%	5.74E-05
97.5%	7.10E-05
100.0%	1.13E-04

End of Forecast

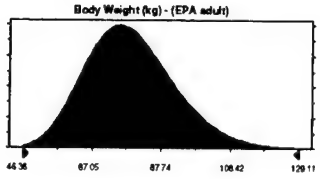
Assumptions

Assumption: Body Weight (kg) - (EPA adult) **(GW-EPA.XLS)Sheet1 - Cell: C8**

Lognormal distribution with parameters:

Mean	78.50
Standard Dev.	13.50

Selected range is from 0.00 to +Infinity
Mean value in simulation was 78.22

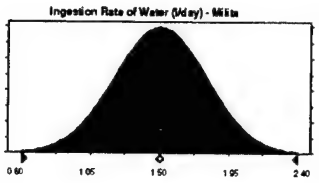


Assumption: Ingestion Rate of Water (l/day) - Milita **(GW-EPA.XLS)Sheet1 - Cell: C11**

Normal distribution with parameters:

Mean	1.50
Standard Dev.	0.30

Selected range is from -Infinity to +Infinity
Mean value in simulation was 1.50

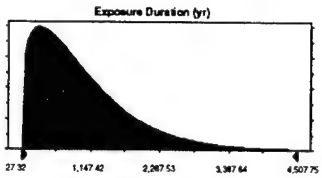


Assumption: Exposure Duration (yr) **(GW-EPA.XLS)Sheet1 - Cell: C9**

Weibull distribution with parameters:

Location	27.32
Scale	1,052.92
Shape	1.236289091

Selected range is from 27.32 to 6,390.00
Mean value in simulation was 1,003.91

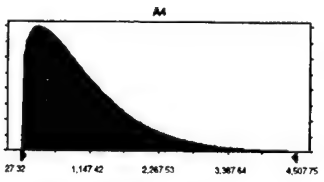


Assumption: A4 **(CANNON.XLS)Sheet1 - Cell: A4**

Weibull distribution with parameters:

Location	27.32
Scale	1,052.92
Shape	1.236289091

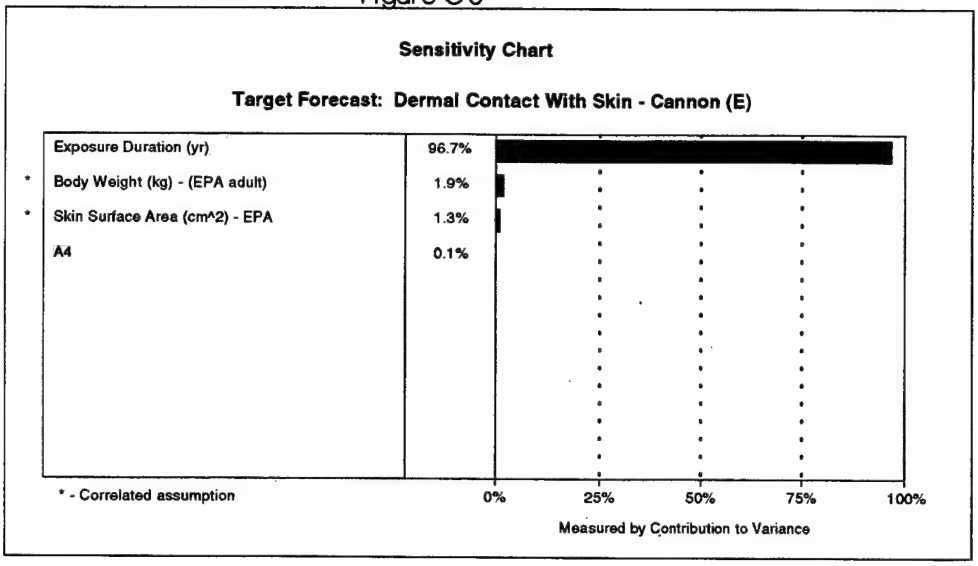
Selected range is from 27.32 to 6,390.00
Mean value in simulation was 1,009.29



End of Assumptions

Crystal Ball Report
Simulation started on 10/7/99 at 11:45:35
Simulation stopped on 10/7/99 at 11:45:54

Figure C-5

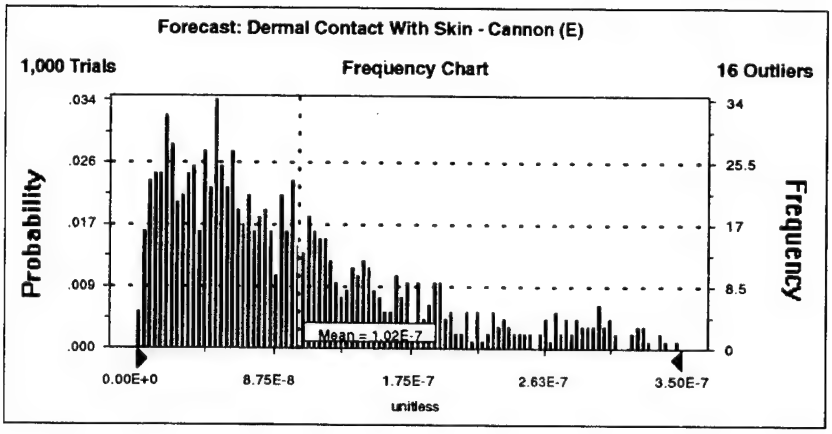


Forecast: Dermal Contact With Skin - Cannon (E) **Cell: C23**

Summary:

Display Range is from 0.00E+0 to 3.50E-7 unitless
Entire Range is from 2.34E-9 to 5.32E-7 unitless
After 1,000 Trials, the Std. Error of the Mean is 2.71E-9

Statistics:	Value
Trials	1000
Mean	1.03E-07
Median	7.91E-08
Mode	---
Standard Deviation	8.56E-08
Variance	7.34E-15
Skewness	1.44E+00
Kurtosis	5.19E+00
Coeff. of Variability	8.34E-01
Range Minimum	2.34E-09
Range Maximum	5.32E-07
Range Width	5.30E-07
Mean Std. Error	2.71E-09



Forecast: Dermal Contact With Skin - Cannon (E) (cont'd) **Cell: C23**

Percentiles:

Percentile	unitless
0.0%	2.34E-09
2.5%	7.77E-09
5.0%	1.16E-08
50.0%	7.91E-08
95.0%	2.89E-07
97.5%	3.24E-07
100.0%	5.32E-07

End of Forecast

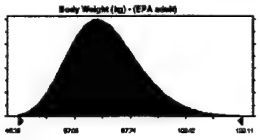
Assumptions

Assumption: Body Weight (kg) - (EPA adult) **(DERM.XLS)Sheet1 - Cell: C8**

Lognormal distribution with parameters:

Mean	78.50
Standard Dev.	13.50

Selected range is from 0.00 to +Infinity
Mean value in simulation was 78.07



Correlated with:

Skin Surface Area (cm^2) - EPA (C11)	0.95

Assumption: Skin Surface Area (cm^2) - EPA **(DERM.XLS)Sheet1 - Cell: C11**

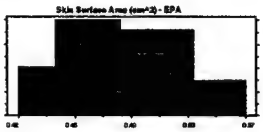
Custom distribution with parameters:

			Relative Prob.	
Continuous range	0.42	to	0.44	0.100000
Continuous range	0.44	to	0.49	0.350000
Continuous range	0.49	to	0.54	0.350000
Continuous range	0.54	to	0.57	0.100000
Total Relative Probability				0.900000

Mean value in simulation was 0.49

Correlated with:

Body Weight (kg) - (EPA adult) (C8)	0.95



Assumption: Exposure Duration (yr) **(DERM.XLS)Sheet1 - Cell: C9**

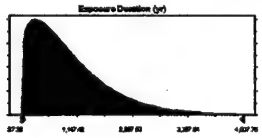
Weibull distribution with parameters:

Location	27.32
Scale	1,052.92
Shape	1.236289091

Selected range is from 27.32 to 6,390.00

Assumption: Exposure Duration (yr) (cont'd) **(DERM.XLS)Sheet1 - Cell: C9**

Mean value in simulation was 1,027.36

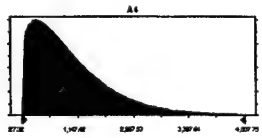


Assumption: A4 **(CANNON.XLS)Sheet1 - Cell: A4**

Weibull distribution with parameters:

Location	27.32
Scale	1,052.92
Shape	1.236289091

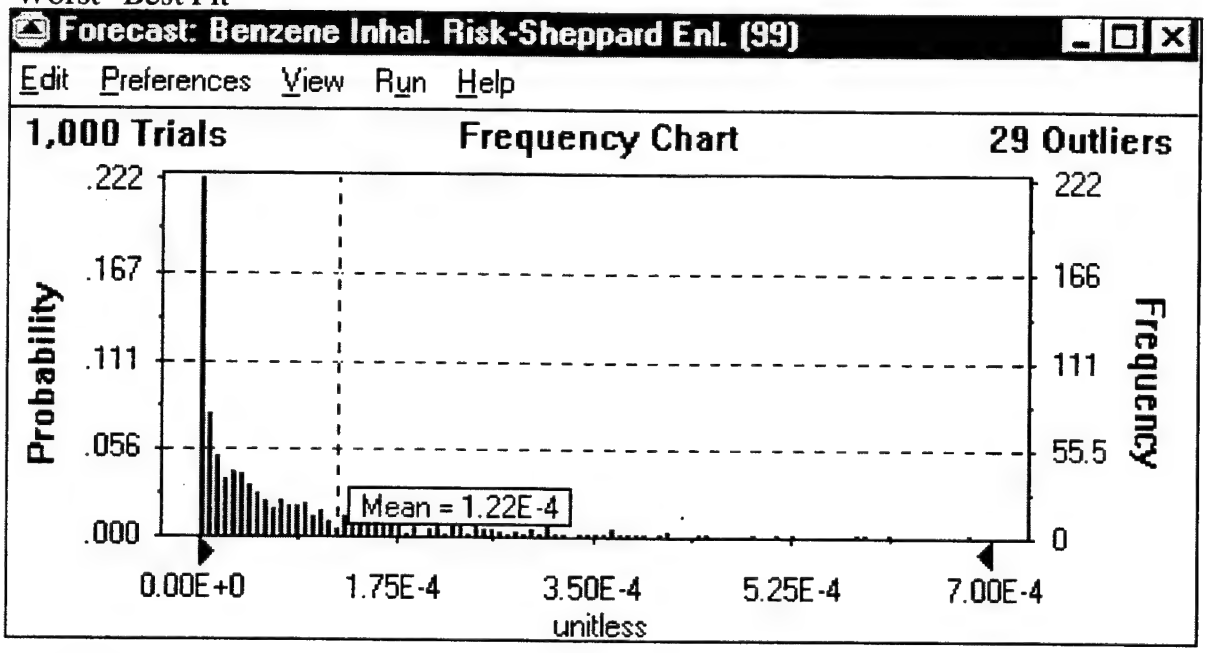
Selected range is from 27.32 to 6,390.00
Mean value in simulation was 1,011.32



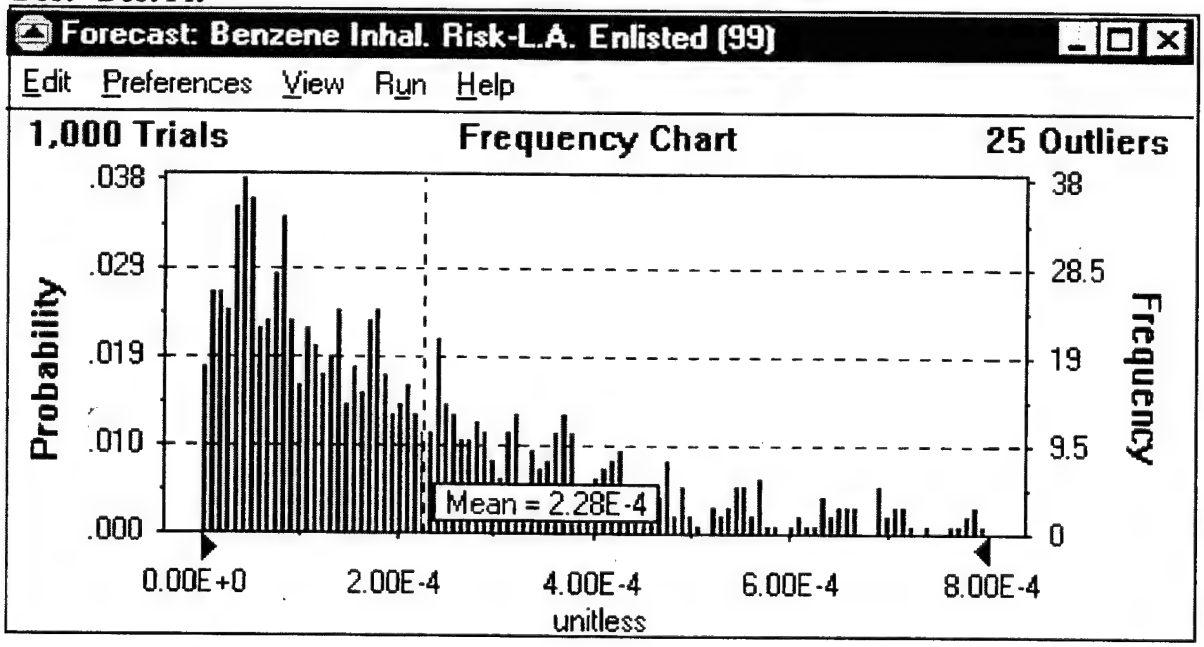
End of Assumptions

Figure C-6
Benzene Indoor Inhalation Risk Estimate Simulation
Worst "Best Fit" vs. Best "Best Fit" of Time-on-Station Distribution Trials

Worst "Best Fit"



Best "Best Fit"



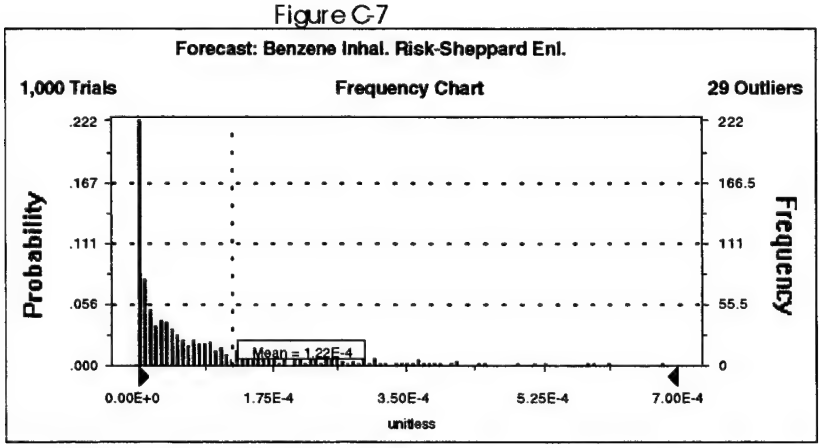
Crystal Ball Report
Simulation started on 12/28/99 at 11:02:51
Simulation stopped on 12/28/99 at 11:02:58

Forecast: Benzene Inhal. Risk-Sheppard Enl. **Cell: C23**

Summary:
Display Range is from 0.00E+0 to 7.00E-4 unitless
Entire Range is from 5.71E-8 to 1.49E-3 unitless
After 1,000 Trials, the Std. Error of the Mean is 6.05E-6

Statistics:	Value
Trials	1000
Mean	1.22E-04
Median	4.88E-05
Mode	---
Standard Deviation	1.91E-04
Variance	3.66E-08
Skewness	2.99E+00
Kurtosis	1.41E+01
Coeff. of Variability	1.56E+00
Range Minimum	5.71E-08
Range Maximum	1.50E-03
Range Width	1.50E-03
Mean Std. Error	6.05E-06

Figure C-7



Forecast: Benzene Inhal. Risk-Sheppard Enl. (cont'd) **Cell: C23**

Percentiles:

Percentile	unitless
0.0%	5.71E-08
2.5%	3.57E-07
5.0%	8.37E-07
50.0%	4.88E-05
95.0%	4.95E-04
97.5%	7.52E-04
100.0%	1.50E-03

Frequency Counts:

Frequency:

Group	Start Value	End Value	Prob.	Freq.
	-Infinity	0.00E+00	0.000000	0
1	0.00E+00	7.00E-06	0.222000	222
2	7.00E-06	1.40E-05	0.078000	78
3	1.40E-05	2.10E-05	0.051000	51
4	2.10E-05	2.80E-05	0.037000	37
5	2.80E-05	3.50E-05	0.041000	41
6	3.50E-05	4.20E-05	0.039000	39
7	4.20E-05	4.90E-05	0.033000	33
8	4.90E-05	5.60E-05	0.028000	28
9	5.60E-05	6.30E-05	0.023000	23
10	6.30E-05	7.00E-05	0.019000	19
11	7.00E-05	7.70E-05	0.024000	24
12	7.70E-05	8.40E-05	0.020000	20
13	8.40E-05	9.10E-05	0.020000	20
14	9.10E-05	9.80E-05	0.022000	22
15	9.80E-05	1.05E-04	0.014000	14
16	1.05E-04	1.12E-04	0.017000	17
17	1.12E-04	1.19E-04	0.011000	11
18	1.19E-04	1.26E-04	0.006000	6
19	1.26E-04	1.33E-04	0.013000	13
20	1.33E-04	1.40E-04	0.012000	12
21	1.40E-04	1.47E-04	0.015000	15
22	1.47E-04	1.54E-04	0.014000	14
23	1.54E-04	1.61E-04	0.012000	12
24	1.61E-04	1.68E-04	0.011000	11
25	1.68E-04	1.75E-04	0.008000	8
26	1.75E-04	1.82E-04	0.008000	8
27	1.82E-04	1.89E-04	0.003000	3
28	1.89E-04	1.96E-04	0.008000	8

Forecast: Benzene Inhal. Risk-Sheppard Enl. (cont'd) **Cell: C23**

Group	Start Value	End Value	Prob.	Freq.
29	1.96E-04	2.03E-04	0.001000	1
30	2.03E-04	2.10E-04	0.005000	5
31	2.10E-04	2.17E-04	0.009000	9
32	2.17E-04	2.24E-04	0.002000	2
33	2.24E-04	2.31E-04	0.008000	8
34	2.31E-04	2.38E-04	0.012000	12
35	2.38E-04	2.45E-04	0.003000	3
36	2.45E-04	2.52E-04	0.011000	11
37	2.52E-04	2.59E-04	0.005000	5
38	2.59E-04	2.66E-04	0.005000	5
39	2.66E-04	2.73E-04	0.004000	4
40	2.73E-04	2.80E-04	0.002000	2
41	2.80E-04	2.87E-04	0.004000	4
42	2.87E-04	2.94E-04	0.002000	2
43	2.94E-04	3.01E-04	0.006000	6
44	3.01E-04	3.08E-04	0.003000	3
45	3.08E-04	3.15E-04	0.008000	8
46	3.15E-04	3.22E-04	0.002000	2
47	3.22E-04	3.29E-04	0.003000	3
48	3.29E-04	3.36E-04	0.001000	1
49	3.36E-04	3.43E-04	0.003000	3
50	3.43E-04	3.50E-04	0.002000	2
51	3.50E-04	3.57E-04	0.003000	3
52	3.57E-04	3.64E-04	0.002000	2
53	3.64E-04	3.71E-04	0.005000	5
54	3.71E-04	3.78E-04	0.002000	2
55	3.78E-04	3.85E-04	0.003000	3
56	3.85E-04	3.92E-04	0.003000	3
57	3.92E-04	3.99E-04	0.003000	3
58	3.99E-04	4.06E-04	0.000000	0
59	4.06E-04	4.13E-04	0.003000	3
60	4.13E-04	4.20E-04	0.004000	4
61	4.20E-04	4.27E-04	0.001000	1
62	4.27E-04	4.34E-04	0.001000	1
63	4.34E-04	4.41E-04	0.000000	0
64	4.41E-04	4.48E-04	0.002000	2
65	4.48E-04	4.55E-04	0.002000	2
66	4.55E-04	4.62E-04	0.001000	1
67	4.62E-04	4.69E-04	0.000000	0
68	4.69E-04	4.76E-04	0.001000	1
69	4.76E-04	4.83E-04	0.001000	1
70	4.83E-04	4.90E-04	0.001000	1

Forecast: Benzene Inhal. Risk-Sheppard Enl. (cont'd) **Cell: C23**

Group	Start Value	End Value	Prob.	Freq.
71	4.90E-04	4.97E-04	0.002000	2
72	4.97E-04	5.04E-04	0.000000	0
73	5.04E-04	5.11E-04	0.000000	0
74	5.11E-04	5.18E-04	0.002000	2
75	5.18E-04	5.25E-04	0.001000	1
76	5.25E-04	5.32E-04	0.003000	3
77	5.32E-04	5.39E-04	0.000000	0
78	5.39E-04	5.46E-04	0.001000	1
79	5.46E-04	5.53E-04	0.000000	0
80	5.53E-04	5.60E-04	0.000000	0
81	5.60E-04	5.67E-04	0.001000	1
82	5.67E-04	5.74E-04	0.000000	0
83	5.74E-04	5.81E-04	0.000000	0
84	5.81E-04	5.88E-04	0.003000	3
85	5.88E-04	5.95E-04	0.002000	2
86	5.95E-04	6.02E-04	0.000000	0
87	6.02E-04	6.09E-04	0.000000	0
88	6.09E-04	6.16E-04	0.002000	2
89	6.16E-04	6.23E-04	0.000000	0
90	6.23E-04	6.30E-04	0.000000	0
91	6.30E-04	6.37E-04	0.000000	0
92	6.37E-04	6.44E-04	0.001000	1
93	6.44E-04	6.51E-04	0.000000	0
94	6.51E-04	6.58E-04	0.000000	0
95	6.58E-04	6.65E-04	0.000000	0
96	6.65E-04	6.72E-04	0.001000	1
97	6.72E-04	6.79E-04	0.000000	0
98	6.79E-04	6.86E-04	0.002000	2
99	6.86E-04	6.93E-04	0.001000	1
100	6.93E-04	7.00E-04	0.001000	1
	7.00E-04	+Infinity	0.029000	29
Total:			1.000000	1000

Cumulative:

Group	Start Value	End Value	Prob.	Freq.
	-Infinity	0.00E+00	0.000000	0
1	0.00E+00	7.00E-06	0.222000	222
2	7.00E-06	1.40E-05	0.300000	300
3	1.40E-05	2.10E-05	0.351000	351
4	2.10E-05	2.80E-05	0.388000	388
5	2.80E-05	3.50E-05	0.429000	429
6	3.50E-05	4.20E-05	0.468000	468

Forecast: Benzene Inhal. Risk-Sheppard Enl. (cont'd) **Cell: C23**

Group	Start Value	End Value	Prob.	Freq.
7	4.20E-05	4.90E-05	0.501000	501
8	4.90E-05	5.60E-05	0.529000	529
9	5.60E-05	6.30E-05	0.552000	552
10	6.30E-05	7.00E-05	0.571000	571
11	7.00E-05	7.70E-05	0.595000	595
12	7.70E-05	8.40E-05	0.615000	615
13	8.40E-05	9.10E-05	0.635000	635
14	9.10E-05	9.80E-05	0.657000	657
15	9.80E-05	1.05E-04	0.671000	671
16	1.05E-04	1.12E-04	0.688000	688
17	1.12E-04	1.19E-04	0.699000	699
18	1.19E-04	1.26E-04	0.705000	705
19	1.26E-04	1.33E-04	0.718000	718
20	1.33E-04	1.40E-04	0.730000	730
21	1.40E-04	1.47E-04	0.745000	745
22	1.47E-04	1.54E-04	0.759000	759
23	1.54E-04	1.61E-04	0.771000	771
24	1.61E-04	1.68E-04	0.782000	782
25	1.68E-04	1.75E-04	0.790000	790
26	1.75E-04	1.82E-04	0.798000	798
27	1.82E-04	1.89E-04	0.801000	801
28	1.89E-04	1.96E-04	0.809000	809
29	1.96E-04	2.03E-04	0.810000	810
30	2.03E-04	2.10E-04	0.815000	815
31	2.10E-04	2.17E-04	0.824000	824
32	2.17E-04	2.24E-04	0.826000	826
33	2.24E-04	2.31E-04	0.834000	834
34	2.31E-04	2.38E-04	0.846000	846
35	2.38E-04	2.45E-04	0.849000	849
36	2.45E-04	2.52E-04	0.860000	860
37	2.52E-04	2.59E-04	0.865000	865
38	2.59E-04	2.66E-04	0.870000	870
39	2.66E-04	2.73E-04	0.874000	874
40	2.73E-04	2.80E-04	0.876000	876
41	2.80E-04	2.87E-04	0.880000	880
42	2.87E-04	2.94E-04	0.882000	882
43	2.94E-04	3.01E-04	0.888000	888
44	3.01E-04	3.08E-04	0.891000	891
45	3.08E-04	3.15E-04	0.899000	899
46	3.15E-04	3.22E-04	0.901000	901
47	3.22E-04	3.29E-04	0.904000	904
48	3.29E-04	3.36E-04	0.905000	905

Forecast: Benzene Inhal. Risk-Sheppard Enl. (cont'd) **Cell: C23**

Group	tart Value	End Value	Prob.	Freq.
49	3.36E-04	3.43E-04	0.908000	908
50	3.43E-04	3.50E-04	0.910000	910
51	3.50E-04	3.57E-04	0.913000	913
52	3.57E-04	3.64E-04	0.915000	915
53	3.64E-04	3.71E-04	0.920000	920
54	3.71E-04	3.78E-04	0.922000	922
55	3.78E-04	3.85E-04	0.925000	925
56	3.85E-04	3.92E-04	0.928000	928
57	3.92E-04	3.99E-04	0.931000	931
58	3.99E-04	4.06E-04	0.931000	931
59	4.06E-04	4.13E-04	0.934000	934
60	4.13E-04	4.20E-04	0.938000	938
61	4.20E-04	4.27E-04	0.939000	939
62	4.27E-04	4.34E-04	0.940000	940
63	4.34E-04	4.41E-04	0.940000	940
64	4.41E-04	4.48E-04	0.942000	942
65	4.48E-04	4.55E-04	0.944000	944
66	4.55E-04	4.62E-04	0.945000	945
67	4.62E-04	4.69E-04	0.945000	945
68	4.69E-04	4.76E-04	0.946000	946
69	4.76E-04	4.83E-04	0.947000	947
70	4.83E-04	4.90E-04	0.948000	948
71	4.90E-04	4.97E-04	0.950000	950
72	4.97E-04	5.04E-04	0.950000	950
73	5.04E-04	5.11E-04	0.950000	950
74	5.11E-04	5.18E-04	0.952000	952
75	5.18E-04	5.25E-04	0.953000	953
76	5.25E-04	5.32E-04	0.956000	956
77	5.32E-04	5.39E-04	0.956000	956
78	5.39E-04	5.46E-04	0.957000	957
79	5.46E-04	5.53E-04	0.957000	957
80	5.53E-04	5.60E-04	0.957000	957
81	5.60E-04	5.67E-04	0.958000	958
82	5.67E-04	5.74E-04	0.958000	958
83	5.74E-04	5.81E-04	0.958000	958
84	5.81E-04	5.88E-04	0.961000	961
85	5.88E-04	5.95E-04	0.963000	963
86	5.95E-04	6.02E-04	0.963000	963
87	6.02E-04	6.09E-04	0.963000	963
88	6.09E-04	6.16E-04	0.965000	965
89	6.16E-04	6.23E-04	0.965000	965
90	6.23E-04	6.30E-04	0.965000	965
91	6.30E-04	6.37E-04	0.965000	965
92	6.37E-04	6.44E-04	0.966000	966
93	6.44E-04	6.51E-04	0.966000	966
94	6.51E-04	6.58E-04	0.966000	966
95	6.58E-04	6.65E-04	0.966000	966
96	6.65E-04	6.72E-04	0.967000	967
97	6.72E-04	6.79E-04	0.967000	967
98	6.79E-04	6.86E-04	0.969000	969
99	6.86E-04	6.93E-04	0.970000	970
100	6.93E-04	7.00E-04	0.971000	971
	7.00E-04	+Infinity	1.000000	1000

End of Forecast

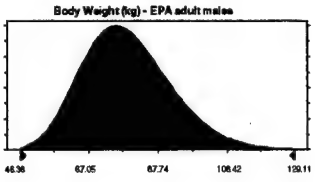
Assumptions

Assumption: Body Weight (kg) - EPA adult males **(inhal-epa.XLS)Sheet1 - Cell: C8**

Lognormal distribution with parameters:

Mean	78.50
Standard Dev.	13.50

Selected range is from 0.00 to +Infinity
Mean value in simulation was 78.63

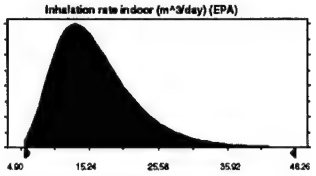


Assumption: Inhalation rate indoor (m^3/day) (EPA) **(inhal-epa.XLS)Sheet1 - Cell: C11**

Lognormal distribution with parameters:

Mean	16.15
Standard Dev.	6.26

Selected range is from 5.40 to 64.95
Mean value in simulation was 16.26

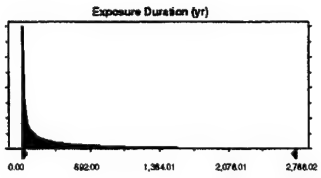


Assumption: Exposure Duration (yr) **(inhal-epa.XLS)Sheet1 - Cell: C9**

Beta distribution with parameters:

Alpha	0.40
Beta	16.42
Scale	18,872.86

Selected range is from 1.00 to 9,343.00
Mean value in simulation was 540.36

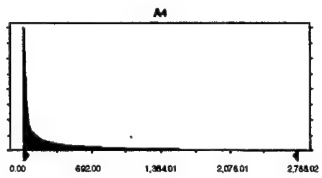


Assumption: A4 **(SHEPPARD_99.xls)Sheet1 - Cell: A4**

Beta distribution with parameters:

Alpha	0.40
Beta	16.42
Scale	18,872.86

Selected range is from 1.00 to 9,343.00
Mean value in simulation was 505.20



End of Assumptions

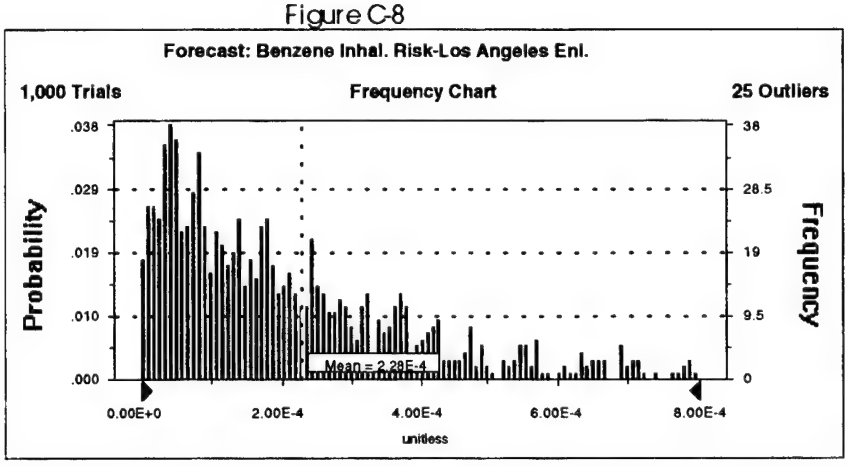
Crystal Ball Report
Simulation started on 12/28/99 at 11:09:27
Simulation stopped on 12/28/99 at 11:09:31

Forecast: Benzene Inhal. Risk-Los Angeles Enl. **Cell: C23**

Summary:
Display Range is from 0.00E+0 to 8.00E-4 unitless
Entire Range is from 2.83E-7 to 1.75E-3 unitless
After 1,000 Trials, the Std. Error of the Mean is 6.91E-6

Statistics:	Value
Trials	1000
Mean	2.28E-04
Median	1.68E-04
Mode	---
Standard Deviation	2.18E-04
Variance	4.77E-08
Skewness	2.07E+00
Kurtosis	9.60E+00
Coeff. of Variability	9.59E-01
Range Minimum	2.83E-07
Range Maximum	1.75E-03
Range Width	1.75E-03
Mean Std. Error	6.91E-06

Figure C-8



Forecast: Benzene Inhal. Risk-Los Angeles Enl. (cont'd) **Cell: C23**

Percentiles:

Percentile	unitless
0.0%	2.83E-07
2.5%	1.01E-05
5.0%	1.77E-05
50.0%	1.68E-04
95.0%	6.67E-04
97.5%	7.95E-04
100.0%	1.75E-03

Frequency Counts:

Frequency:

Group	Start Value	End Value	Prob.	Freq.
	-Infinity	0.00E+00	0.000000	0
1	0.00E+00	8.00E-06	0.018000	18
2	8.00E-06	1.60E-05	0.026000	26
3	1.60E-05	2.40E-05	0.026000	26
4	2.40E-05	3.20E-05	0.024000	24
5	3.20E-05	4.00E-05	0.035000	35
6	4.00E-05	4.80E-05	0.038000	38
7	4.80E-05	5.60E-05	0.036000	36
8	5.60E-05	6.40E-05	0.022000	22
9	6.40E-05	7.20E-05	0.023000	23
10	7.20E-05	8.00E-05	0.028000	28
11	8.00E-05	8.80E-05	0.034000	34
12	8.80E-05	9.60E-05	0.023000	23
13	9.60E-05	1.04E-04	0.016000	16
14	1.04E-04	1.12E-04	0.022000	22
15	1.12E-04	1.20E-04	0.020000	20
16	1.20E-04	1.28E-04	0.017000	17
17	1.28E-04	1.36E-04	0.019000	19
18	1.36E-04	1.44E-04	0.024000	24
19	1.44E-04	1.52E-04	0.014000	14
20	1.52E-04	1.60E-04	0.018000	18
21	1.60E-04	1.68E-04	0.015000	15
22	1.68E-04	1.76E-04	0.023000	23
23	1.76E-04	1.84E-04	0.024000	24
24	1.84E-04	1.92E-04	0.017000	17
25	1.92E-04	2.00E-04	0.013000	13
26	2.00E-04	2.08E-04	0.014000	14
27	2.08E-04	2.16E-04	0.016000	16
28	2.16E-04	2.24E-04	0.013000	13

Forecast: Benzene Inhal. Risk-Los Angeles Enl. (cont'd) **Cell: C23**

Group	Start Value	End Value	Prob.	Freq.
29	2.24E-04	2.32E-04	0.011000	11
30	2.32E-04	2.40E-04	0.011000	11
31	2.40E-04	2.48E-04	0.021000	21
32	2.48E-04	2.56E-04	0.014000	14
33	2.56E-04	2.64E-04	0.013000	13
34	2.64E-04	2.72E-04	0.010000	10
35	2.72E-04	2.80E-04	0.010000	10
36	2.80E-04	2.88E-04	0.012000	12
37	2.88E-04	2.96E-04	0.011000	11
38	2.96E-04	3.04E-04	0.008000	8
39	3.04E-04	3.12E-04	0.006000	6
40	3.12E-04	3.20E-04	0.011000	11
41	3.20E-04	3.28E-04	0.013000	13
42	3.28E-04	3.36E-04	0.003000	3
43	3.36E-04	3.44E-04	0.009000	9
44	3.44E-04	3.52E-04	0.007000	7
45	3.52E-04	3.60E-04	0.008000	8
46	3.60E-04	3.68E-04	0.011000	11
47	3.68E-04	3.76E-04	0.013000	13
48	3.76E-04	3.84E-04	0.011000	11
49	3.84E-04	3.92E-04	0.004000	4
50	3.92E-04	4.00E-04	0.005000	5
51	4.00E-04	4.08E-04	0.006000	6
52	4.08E-04	4.16E-04	0.007000	7
53	4.16E-04	4.24E-04	0.008000	8
54	4.24E-04	4.32E-04	0.009000	9
55	4.32E-04	4.40E-04	0.003000	3
56	4.40E-04	4.48E-04	0.003000	3
57	4.48E-04	4.56E-04	0.003000	3
58	4.56E-04	4.64E-04	0.003000	3
59	4.64E-04	4.72E-04	0.004000	4
60	4.72E-04	4.80E-04	0.008000	8
61	4.80E-04	4.88E-04	0.002000	2
62	4.88E-04	4.96E-04	0.005000	5
63	4.96E-04	5.04E-04	0.002000	2
64	5.04E-04	5.12E-04	0.001000	1
65	5.12E-04	5.20E-04	0.000000	0
66	5.20E-04	5.28E-04	0.003000	3
67	5.28E-04	5.36E-04	0.002000	2
68	5.36E-04	5.44E-04	0.003000	3
69	5.44E-04	5.52E-04	0.005000	5
70	5.52E-04	5.60E-04	0.005000	5

Forecast: Benzene Inhal. Risk-Los Angeles Enl. (cont'd) **Cell: C23**

Group	Start Value	End Value	Prob.	Freq.
71	5.60E-04	5.68E-04	0.002000	2
72	5.68E-04	5.76E-04	0.006000	6
73	5.76E-04	5.84E-04	0.001000	1
74	5.84E-04	5.92E-04	0.001000	1
75	5.92E-04	6.00E-04	0.000000	0
76	6.00E-04	6.08E-04	0.001000	1
77	6.08E-04	6.16E-04	0.002000	2
78	6.16E-04	6.24E-04	0.001000	1
79	6.24E-04	6.32E-04	0.001000	1
80	6.32E-04	6.40E-04	0.004000	4
81	6.40E-04	6.48E-04	0.002000	2
82	6.48E-04	6.56E-04	0.003000	3
83	6.56E-04	6.64E-04	0.003000	3
84	6.64E-04	6.72E-04	0.003000	3
85	6.72E-04	6.80E-04	0.000000	0
86	6.80E-04	6.88E-04	0.000000	0
87	6.88E-04	6.96E-04	0.005000	5
88	6.96E-04	7.04E-04	0.002000	2
89	7.04E-04	7.12E-04	0.003000	3
90	7.12E-04	7.20E-04	0.003000	3
91	7.20E-04	7.28E-04	0.001000	1
92	7.28E-04	7.36E-04	0.000000	0
93	7.36E-04	7.44E-04	0.001000	1
94	7.44E-04	7.52E-04	0.000000	0
95	7.52E-04	7.60E-04	0.000000	0
96	7.60E-04	7.68E-04	0.001000	1
97	7.68E-04	7.76E-04	0.001000	1
98	7.76E-04	7.84E-04	0.002000	2
99	7.84E-04	7.92E-04	0.003000	3
100	7.92E-04	8.00E-04	0.001000	1
	8.00E-04	+Infinity	0.025000	25
Total:			1.000000	1000

Cumulative:

Group	Start Value	End Value	Prob.	Freq.
	-Infinity	0.00E+00	0.000000	0
1	0.00E+00	8.00E-06	0.018000	18
2	8.00E-06	1.60E-05	0.044000	44
3	1.60E-05	2.40E-05	0.070000	70
4	2.40E-05	3.20E-05	0.094000	94
5	3.20E-05	4.00E-05	0.129000	129
6	4.00E-05	4.80E-05	0.167000	167

Forecast: Benzene Inhal. Risk-Los Angeles Enl. (cont'd) **Cell: C23**

Group	tart Value	End Value	Prob.	Freq.
7	4.80E-05	5.60E-05	0.203000	203
8	5.60E-05	6.40E-05	0.225000	225
9	6.40E-05	7.20E-05	0.248000	248
10	7.20E-05	8.00E-05	0.276000	276
11	8.00E-05	8.80E-05	0.310000	310
12	8.80E-05	9.60E-05	0.333000	333
13	9.60E-05	1.04E-04	0.349000	349
14	1.04E-04	1.12E-04	0.371000	371
15	1.12E-04	1.20E-04	0.391000	391
16	1.20E-04	1.28E-04	0.408000	408
17	1.28E-04	1.36E-04	0.427000	427
18	1.36E-04	1.44E-04	0.451000	451
19	1.44E-04	1.52E-04	0.465000	465
20	1.52E-04	1.60E-04	0.483000	483
21	1.60E-04	1.68E-04	0.498000	498
22	1.68E-04	1.76E-04	0.521000	521
23	1.76E-04	1.84E-04	0.545000	545
24	1.84E-04	1.92E-04	0.562000	562
25	1.92E-04	2.00E-04	0.575000	575
26	2.00E-04	2.08E-04	0.589000	589
27	2.08E-04	2.16E-04	0.605000	605
28	2.16E-04	2.24E-04	0.618000	618
29	2.24E-04	2.32E-04	0.629000	629
30	2.32E-04	2.40E-04	0.640000	640
31	2.40E-04	2.48E-04	0.661000	661
32	2.48E-04	2.56E-04	0.675000	675
33	2.56E-04	2.64E-04	0.688000	688
34	2.64E-04	2.72E-04	0.698000	698
35	2.72E-04	2.80E-04	0.708000	708
36	2.80E-04	2.88E-04	0.720000	720
37	2.88E-04	2.96E-04	0.731000	731
38	2.96E-04	3.04E-04	0.739000	739
39	3.04E-04	3.12E-04	0.745000	745
40	3.12E-04	3.20E-04	0.756000	756
41	3.20E-04	3.28E-04	0.769000	769
42	3.28E-04	3.36E-04	0.772000	772
43	3.36E-04	3.44E-04	0.781000	781
44	3.44E-04	3.52E-04	0.788000	788
45	3.52E-04	3.60E-04	0.796000	796
46	3.60E-04	3.68E-04	0.807000	807
47	3.68E-04	3.76E-04	0.820000	820
48	3.76E-04	3.84E-04	0.831000	831
49	3.84E-04	3.92E-04	0.835000	835
50	3.92E-04	4.00E-04	0.840000	840
51	4.00E-04	4.08E-04	0.846000	846
52	4.08E-04	4.16E-04	0.853000	853
53	4.16E-04	4.24E-04	0.861000	861

Forecast: Benzene Inhal. Risk-Los Angeles Enl. (cont'd) **Cell: C23**

Group	tart Value	End Value	Prob.	Freq.
54	4.24E-04	4.32E-04	0.870000	870
55	4.32E-04	4.40E-04	0.873000	873
56	4.40E-04	4.48E-04	0.876000	876
57	4.48E-04	4.56E-04	0.879000	879
58	4.56E-04	4.64E-04	0.882000	882
59	4.64E-04	4.72E-04	0.886000	886
60	4.72E-04	4.80E-04	0.894000	894
61	4.80E-04	4.88E-04	0.896000	896
62	4.88E-04	4.96E-04	0.901000	901
63	4.96E-04	5.04E-04	0.903000	903
64	5.04E-04	5.12E-04	0.904000	904
65	5.12E-04	5.20E-04	0.904000	904
66	5.20E-04	5.28E-04	0.907000	907
67	5.28E-04	5.36E-04	0.909000	909
68	5.36E-04	5.44E-04	0.912000	912
69	5.44E-04	5.52E-04	0.917000	917
70	5.52E-04	5.60E-04	0.922000	922
71	5.60E-04	5.68E-04	0.924000	924
72	5.68E-04	5.76E-04	0.930000	930
73	5.76E-04	5.84E-04	0.931000	931
74	5.84E-04	5.92E-04	0.932000	932
75	5.92E-04	6.00E-04	0.932000	932
76	6.00E-04	6.08E-04	0.933000	933
77	6.08E-04	6.16E-04	0.935000	935
78	6.16E-04	6.24E-04	0.936000	936
79	6.24E-04	6.32E-04	0.937000	937
80	6.32E-04	6.40E-04	0.941000	941
81	6.40E-04	6.48E-04	0.943000	943
82	6.48E-04	6.56E-04	0.946000	946
83	6.56E-04	6.64E-04	0.949000	949
84	6.64E-04	6.72E-04	0.952000	952
85	6.72E-04	6.80E-04	0.952000	952
86	6.80E-04	6.88E-04	0.952000	952
87	6.88E-04	6.96E-04	0.957000	957
88	6.96E-04	7.04E-04	0.959000	959
89	7.04E-04	7.12E-04	0.962000	962
90	7.12E-04	7.20E-04	0.965000	965
91	7.20E-04	7.28E-04	0.966000	966
92	7.28E-04	7.36E-04	0.966000	966
93	7.36E-04	7.44E-04	0.967000	967
94	7.44E-04	7.52E-04	0.967000	967
95	7.52E-04	7.60E-04	0.967000	967
96	7.60E-04	7.68E-04	0.968000	968
97	7.68E-04	7.76E-04	0.969000	969
98	7.76E-04	7.84E-04	0.971000	971
99	7.84E-04	7.92E-04	0.974000	974
100	7.92E-04	8.00E-04	0.975000	975
	8.00E-04	+Infinity	1.000000	1000

End of Forecast

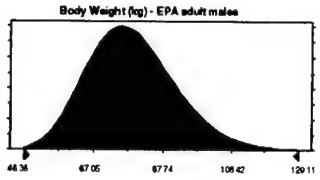
Assumptions

Assumption: Body Weight (kg) - EPA adult males (inhal-epa.XLS)Sheet1 - Cell: C8

Lognormal distribution with parameters:

Mean	78.50
Standard Dev.	13.50

Selected range is from 0.00 to +Infinity
Mean value in simulation was 78.53

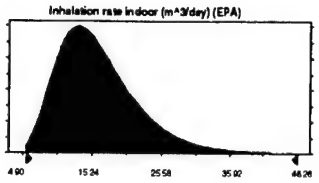


Assumption: Inhalation rate indoor (m^3/day) (EPA) (inhal-epa.XLS)Sheet1 - Cell: C11

Lognormal distribution with parameters:

Mean	16.15
Standard Dev.	6.26

Selected range is from 5.40 to 64.95
Mean value in simulation was 16.55

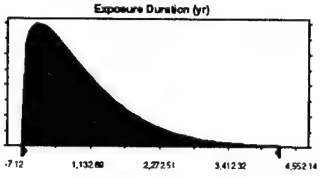


Assumption: Exposure Duration (yr) (inhal-epa.XLS)Sheet1 - Cell: C9

Weibull distribution with parameters:

Location	-7.12
Scale	1,060.30
Shape	1.227423799

Selected range is from 1.00 to 4,291.00
Mean value in simulation was 966.51

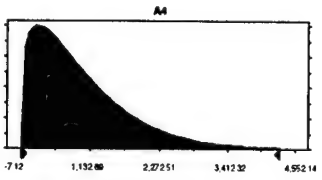


Assumption: A4 (LOS_ANGELES_99.xls)Sheet1 - Cell: A4

Weibull distribution with parameters:

Location	-7.12
Scale	1,060.30
Shape	1.227423799

Selected range is from 1.00 to 4,291.00
Mean value in simulation was 929.80



End of Assumptions

APPENDIX D

Data Set Analysis Process

DATA SET ANALYSIS PROCESS

STEP 1

A MS Access data table matching the input data set was created. For example, the 1987 input data sets (Enl8709 and Off8709 ASCII text files) contained the following fields: SSAN, DOB, DAS, GRADE, DEP, DEP1, DEP2, DEP3, DEP4, DEP5, DEP6, LOCATION, STATION, SEPARATE, DAFSC, DDI. Each of these fields was separated in the text file by a delimiter (i.e., | ["pipe"]). For the 1987 data analysis, the following data table format was used:

SSAN	Text	9 characters	(Social Security Account Number)
DOB	Number	Long Integer	(Date of Birth, yearmonth – YYMM)
DAS	Number	Long Integer	(Date Arrived Station, YYMM)
GRADE	Number	Long Integer	(Grade, 31-39 enlisted; O1-O10 officer)
DEP	Number	Long Integer	(Number of Dependents)
DEP1	Number	Long Integer	(First Dependent, birth year)
DEP2	Number	Long Integer	(Second Dependent, birth year)
DEP3	Number	Long Integer	(Third Dependent, birth year)
DEP4	Number	Long Integer	(Fourth Dependent, birth year)
DEP5	Number	Long Integer	(Fifth Dependent, birth year)
DEP6	Number	Long Integer	(Sixth Dependent, birth year)
LOCATION	Text	30 characters	(Where member works)
STATION	Text	30 characters	(Base of Assignment)
SEPARATE	Text	10 characters	(code assigned by AFPC)
DAFSC	Text	12 characters	(Duty Air Force Specialty Code)
DDI	Number	Long Integer	(Data Identifier – privacy act)

STEP 2

The data table described above was saved using a designator appropriate for the input data set (e.g., for the 1987 data set the table was saved as ENLIST_87).

STEP 3

Steps 1 and 2 were repeated to create an input table for the officer data set (e.g., for the 1987 data set the table was saved as OFFICER_87).

STEP 4

The ASCII text files (e.g., Enl8709, and Off8709) were imported into the MS Access data tables (i.e., into ENLIST_87 from the Enl8709 data set and into OFFICER_87 from the Off8709 data set). The import feature in MS Access in located in the File menu under "Get External Data".

STEP 5

A Make Table Query was performed on the MS Access data tables prepared under STEP 4 to develop Enlist_YY_on_Station and Officer_YY_on_Station data tables to support the data analysis using the following input fields:

SSAN – same as input table

BIRTHDATE, using the expression: BIRTHDATE:DateSerial(Left$([Input Table]![DOB],2),Right$([Input Table]![DOB],2),1) **Note:** Input Table for 1987 data is ENLIST_87 or OFFICER_87

DATEARRIVE, using the expression: DATEARRIVE:DateSerial(Left$([Input Table]![DAS],2),Right$([Input Table]![DAS],2),1)

AGE, using the expression: AGE:DateDiff("d", [BIRTHDATE], [Benchmark Date])/365 **Note:** the benchmark date is the download date for the input data set (e.g., 09/01/87 for the Enl8709 and Off8709 ASCII text files)

DOS (for days on station), using the expression: DOS:DateDiff("d", [DATEARRIVE], [Benchmark Date])

GRADE – same as input table

LOCATION – same as input table

STATION – same as input table

DAFSC – same as input table

DAS (date arrived station) – same as input table. **Note:** the Criteria for this field is set to <>9999 to exclude "pipeline" personnel who do not have a date arrived station (i.e., their DAS field is coded 9999)

STEP 6

A query was performed on the tables developed under STEP 5 for the following fields: SSAN, BIRTHDATE, DATEARRIVE, AGE, DOS, GRADE, LOCATION, STATION, DAFSC, DAS. For example, in the Criteria field for LOCATION "ALTUS" was entered and for the STATION field "ALTUS*" was entered (**Note:** the asterisk is a wildcard that instructs the search routine to "look" for any character string that contains ALTUS). In this example, all enlisted or all officer personnel who are both assigned to and located at ALTUS AFB were included in the query. Enlisted or officer personnel who are assigned to ALTUS, but actually located elsewhere (i.e., not at ALTUS AFB) were excluded in the query.

STEP 7

The DOS, AGE, and GRADE columns created by the query performed in STEP 6 on the Enlist_YY_on_Station and Officer_YY_on_Station tables were imported into an MS Excel spreadsheet for each base identified in the 1987 data set as described in STEPS 8 through 10 below.

STEP 8

The DOS column from the enlisted table query was selected and copied into memory, then pasted into the first column (column A) of sheet 1 in a workbook. Cell A1 containing the DOS label was changed to BASE Enlisted. The entire column was sorted in descending order to place the longest days on station data in cell A2 and the shortest days on station at the end of the column (say column A4041 for BASE X). The lower end of the column was inspected for 0 days on station results. If an individual was assigned on the Benchmark Date (e.g., 09/01/87 for the 0987 data set) the DOS result was set to zero. All 0 days were converted to 1 day on station in the spreadsheet. Cells A2 and A3 were selected and moved down using the Insert (cells), move cells down menu. The formula "=MAX(A4:A end of data)" was inserted in cell A2 to display the maximum days on station for BASE Enlisted, and the formula "=MIN(A4:A end of data)" was inserted in cell A3 to display the minimum days on station for BASE Enlisted. The label,

"Time on Station (Days) Distribution – Month and year (of input data, e.g., September 1987) was entered into cell D1 and Maximum and Minimum were entered into cells D2 and D3, respectively.

STEP 9

The AGE column from the enlisted table query was selected and copied into memory, then pasted into the first column (column A) of sheet 2 of the same workbook described under STEP 8 above. Cell A1 containing the AGE label was changed to BASE Enlisted. The entire column was first sorted in ascending order to look for negative ages. If the date of birth (DOB) in the input data was before 1 January 1930, the algorithm used to convert the BIRTHDATE into AGE (i.e., DateDiff Function) produced a negative age. All negative ages found in the AGE column were manually converted into an age by inspecting the BIRTHDATE field in the query. For example, a BIRTHDATE of 6/1/29 resulted in an AGE of –41.778082192 in the query. The actual age for this BIRTHDATE, using the Benchmark Date of 09/01/87, is 58.25 years. After all negative ages were manually converted to actual ages, the AGE column was resorted in descending order to place the oldest person in cell A2 and the youngest person in cell A end of data. Cells A2 and A3 were selected and moved down using the Insert (cells), move cells down menu. The formula "=MAX(A4:A end of data)" was inserted in cell A2 to display the oldest individual for BASE Enlisted, and the formula "=MIN(A4:A end of data)" was inserted in cell A3 to display the youngest individual for BASE Enlisted. The label, "Age Distribution – Month and year (of input data, e.g., September 1987) was entered into cell D1 and Oldest and Youngest were entered into cells D2 and D3, respectively.

STEP 10

The GRADE column from the enlisted table query was selected and copied into memory, then pasted into the first column (column A) of sheet 3 of the same workbook described under STEP 8 above. Cell A1 containing the GRADE label was changed to BASE Enlisted. The entire column was selected and sorted in descending order to place the highest grade in cell A2 and the lowest grade in cell A end of data. Cells A2 and A3 were selected and moved down using the Insert (cells), move cells down menu. The formula "=MAX(A4:A end of data)" was inserted in cell A2 to display the highest grade for BASE Enlisted, and the formula "=MIN(A4:A end of data)" was inserted in cell A3 to display the lowest grade for BASE Enlisted. The label, "Grade Distribution – Month and year (of input data, e.g., September 1987) was entered into cell D1 and Highest and Lowest were entered into cells D2 and D3, respectively.

STEP 11

The DOS, AGE, and GRADE data from the officer table query were entered into the same BASE worksheet in column B using the same process described under STEPS 8 through 10 above. However, BASE Officers labels were used in cell B1 for sheets 1 through 3 in the same BASE workbook.

STEP 12

Descriptive statistics for days on station (DOS) for both enlisted and officer personnel assigned to each base were prepared as sheet 4 in each workbook using the Tools, Data Analysis menu in MS Excel. Two sets of summary statistics, one for enlisted personnel and one for the officers assigned to each base, were prepared. **Note:** the formulas contained in either cell A2 or

A3 were displayed by clicking on one of these cells. The total number of values in the days on station distribution for the enlisted personnel assigned to a base (e.g., 1438 for AFDW, Air Force Department in Washington, D.C.) was used for entry into the input range for the descriptive statistics computations. Similarly, clicking on either cell B2 or cell B3 provided the input range for the officer days on station distribution.

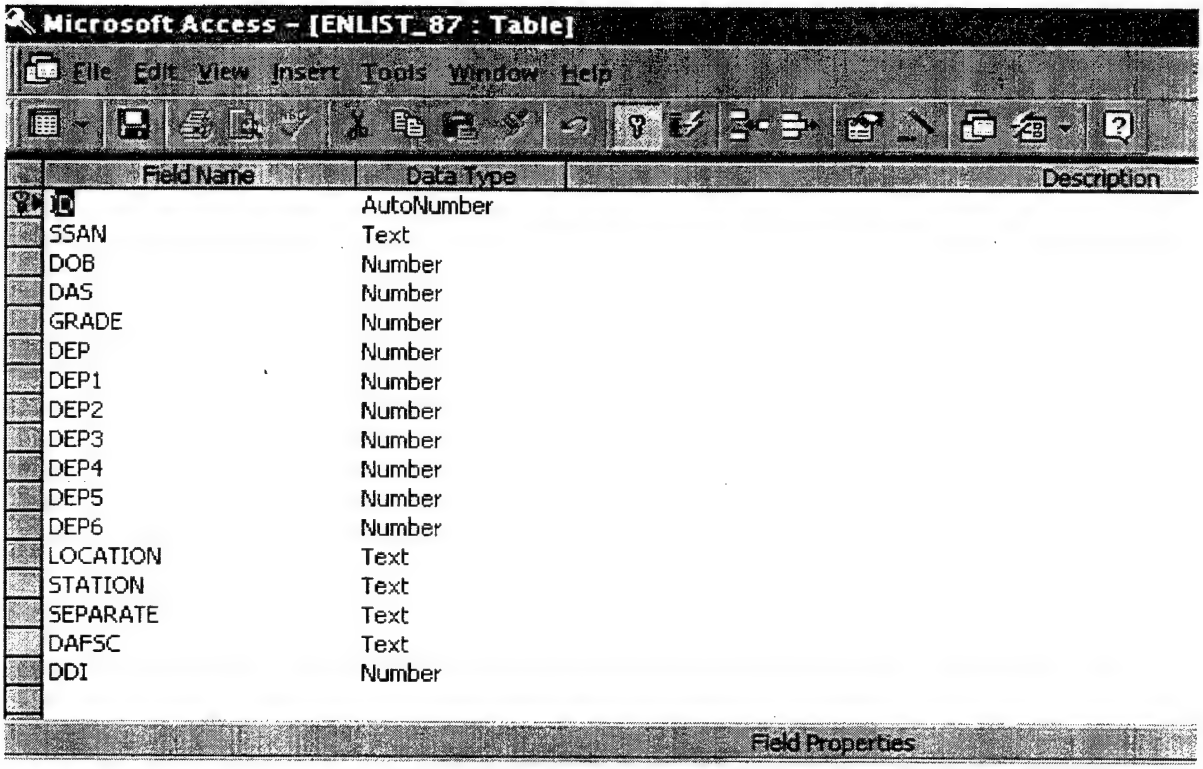
STEP 13

Best fit and normal distribution graphics for both the enlisted and officer days on station distributions in each workbook were developed using the fit distribution gallery routine contained in Crystal Ball. For example, to fit the days on station distribution data for enlisted personnel assigned to the Pentagon the AFDW_87 spreadsheet was opened in Crystal Ball. Clicking on cell A2 or A3 provided the range of values (e.g., A4 through A1441) contained in the distribution. A single value cell (e.g., cell A4) was selected (Crystal Ball will only accept single value cells for the fit distribution gallery routine) and the define assumption toolbar or Cell, Define Assumption menu was selected to bring up the distribution gallery and the fit routine. In the location of data submenu, the Active Worksheet is selected (default) and the Range window activated for input. For the example above, the range A2:A1441 was entered and the NEXT button was selected. This brought up the Fit to Which Distributions and Ranking Method window. By selecting the All Continuous Distributions and Chi-Square Test, clicking on the Show Comparison Chart and Goodness-of-Fit Statistics, and selecting the OK button, the fit routine was run through all continuous distributions in the library that fit the data. The first fit displayed was the best fit based upon the lowest Chi-Square value. In most cases, the best fit for the days on station distributions were not normal or lognormal, but fit weibull, beta, gamma, or extreme value distributions. Consequently, a second fit of the data was performed and the NEXT DISTRIBUTION button was repeatedly selected until the normal distribution fit from the gallery was displayed.

STEP 14

When the best fit graphic was provided by the fit distribution gallery routine in Crystal Ball, the print screen key was pressed to place the image in memory. The Paint software package was run to paste the graphic image into a picture that could be selectively "cut", copied, and pasted onto sheet 1 of the BASE spreadsheet (e.g., into cell D6 on sheet 1 of the AFDW_87 workbook). Each graphic, that is the best fit and normal distribution for both enlisted and officer days on station, was subsequently "cut", copied, and pasted onto each BASE spreadsheet. **Note:** similar fit distribution graphics for the age and grade distributions for Dover AFB, Edwards AFB, Elmendorf AFB, Maxwell AFB, and Minot AFB across all available data sets were also incorporated into their respective spreadsheets.

Figure D-1. Enlisted and Officer Data Tables
1987 Data Set

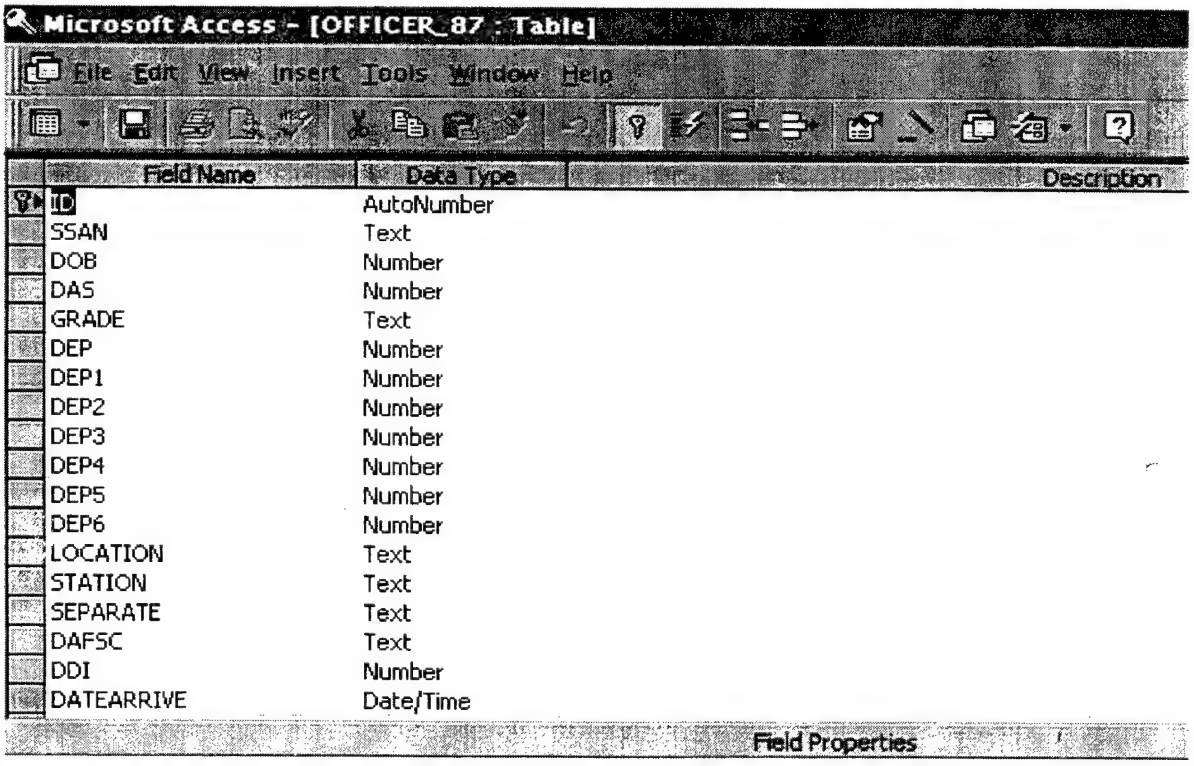


Microsoft Access - [ENLIST_87 : Table]

File Edit View Insert Tools Window Help

Field Name	Data Type	Description
ID	AutoNumber	
SSAN	Text	
DOB	Number	
DAS	Number	
GRADE	Number	
DEP	Number	
DEP1	Number	
DEP2	Number	
DEP3	Number	
DEP4	Number	
DEP5	Number	
DEP6	Number	
LOCATION	Text	
STATION	Text	
SEPARATE	Text	
DAFSC	Text	
DDI	Number	

Field Properties



Microsoft Access - [OFFICER_87 : Table]

File Edit View Insert Tools Window Help

Field Name	Data Type	Description
ID	AutoNumber	
SSAN	Text	
DOB	Number	
DAS	Number	
GRADE	Text	
DEP	Number	
DEP1	Number	
DEP2	Number	
DEP3	Number	
DEP4	Number	
DEP5	Number	
DEP6	Number	
LOCATION	Text	
STATION	Text	
SEPARATE	Text	
DAFSC	Text	
DDI	Number	
DATEARRIVE	Date/Time	

Field Properties

APPENDIX E

Analysis of Additional Data Sets
1987, 1990, 1995, and 1999
Summary of Total Records Available
Enlisted and Officer Personnel
Assigned to and Located at CONUS
And PACAF Bases

Table E-1

ANALYSIS OF ADDITIONAL DATA

1987 Data Set	Total Records	Records Rejected				Total Available	% Used
		DAS=9999	DOB=9999	2-ltr MPF	NAAS		
Enlisted	417,678	1995	10	85040	37,779	292,854	70.1148
Officer	99,987	3421	118	15430	10,426	70,592	70.6012
1990 Data Set							
Enlisted	361,791	1098	4	67194	24964	268,531	74.2227
Officer	92,586	549	36	14136	9873	67,992	73.4366
1995 Data Set							
Enlisted	300,406	640	4	2822	26218	270,722	90.1187
Officer	74,624	534	495	295	9871	63,429	84.9981
1999 Data Set							
Enlisted	268,983	813	4	20	24949	243,197	90.4135
Officer	67,864	1342	157	0	8845	57,520	84.7578
Totals	1,683,919	10,392	828	184,937	152,925	1,334,837	

DAS - Date Assigned Station (coded YYMM)

DOB - Date of Birth (coded YYMM)

Two-Letter Military Personnel Flight (MPF) Codes

NAAS - Not at Assigned Station (located at satellite facility)

Table E-2. Air Force Personnel Assigned to and Located at Listed Air Force Bases

	Number Assigned by Year - Enlisted				Number Assigned by Year - Officer			
Air Force Base	1987	1990	1995	1999	1987	1990	1995	1999
Pentagon	1441	1491	1574	1549	3302	3127	3161	3083
Altus	3352	2953	3050	1683	463	409	405	413
Andersen	3713	2331	2031	1834	385	168	220	211
Andrews	4493	4288	4501	4005	1613	1481	1174	1074
Barksdale	5600	4957	5005	4686	1078	1045	879	799
Beale	3996	3211	3035	2908	597	512	388	351
Bolling	1256	1204	1285	1467	328	307	312	395
Brooks	1178	1129	1216	1057	518	519	656	479
Buckley	0	0	0	732	0	0	0	101
Cannon	3559	3747	4571	2986	421	466	480	300
Charleston	3835	3463	4011	3384	550	573	639	631
Columbus	1976	920	830	571	886	896	506	872
Davis-Monthan	4899	4653	5249	4836	697	605	897	810
Dover	4521	4030	3955	3472	416	409	483	414
Dyess	4997	4483	4342	4024	928	765	712	744
Edwards	3865	3793	3681	2979	775	771	635	554
Eglin	7854	7193	6806	5985	1886	1636	1453	1213
Eielson	3132	2986	2656	2603	346	363	239	267
Ellsworth	5959	5662	3555	2783	996	1054	501	377
Elmendorf	5903	5397	6148	5978	851	892	827	848
F.E. Warren	3509	3005	3223	2921	661	637	634	595
Fairchild	3985	3679	3734	2993	651	653	686	497
Ft George Meade	1958	1862	2325	2278	334	300	328	234
Goodfellow	1790	1650	1837	1644	292	222	322	300
Grand Forks	4761	4205	4183	2506	706	742	836	421
Hanscom	1074	1022	918	814	1160	1090	813	633
Hickam	3709	3358	2707	2581	980	895	709	677
Hill	4630	4280	4056	3654	695	671	641	593
Holloman	5591	4198	4286	3552	759	632	514	414
Hurlburt Field	4183	4616	6606	6271	622	763	1098	1197
Kadena	8617	6860	6864	6283	812	710	748	720
Keesler	9345	7387	6714	6022	1180	1231	1001	922
Kelly	1600	3285	3959	3249	445	823	798	618
Kirtland	3366	3175	3165	2899	1364	1190	1322	1125
Kunsan	2907	2785	2579	2401	257	247	246	254
Lackland	7243	5655	6881	6814	1783	1812	1968	1863
Langley	6861	7149	6703	6625	2201	2075	2034	1853
Laughlin	1968	908	786	560	910	987	486	816
Little Rock	4758	3961	3877	3737	905	719	708	660

Table E-2. Air Force Personnel Assigned to and Located at Listed Air Force Bases (Cont.)

	Number Assigned by Year - Enlisted				Number Assigned by Year - Officer			
Air Force Base	1987	1990	1995	1999	1987	1990	1995	1999
Los Angeles	489	506	549	449	1249	1339	1130	834
Luke	5011	4743	4983	4807	654	707	700	726
MacDill	4252	4504	2306	2826	777	890	581	721
Malmstrom	3371	3556	3725	3082	580	670	660	535
Maxwell	1672	1577	1759	1653	1502	1440	1594	1119
McChord	4662	3341	3597	3005	639	498	555	442
McClellan	2837	2416	2385	1326	480	414	452	222
McConnell	2691	2729	2647	2277	355	381	518	412
McGuire	4355	3929	4541	4039	703	619	806	672
Minot	5367	4402	4664	4071	932	840	761	670
Misawa	3566	3505	3602	3205	320	312	333	335
Moody	1518	2830	3430	3579	273	346	431	434
Mt. Home	3597	3037	3343	3852	435	399	402	519
Nellis	8486	7484	6720	5489	1081	874	856	795
Offutt	9353	9024	7003	6143	3582	3163	1797	1448
Osan	5226	5150	5100	5017	667	589	584	641
Patrick	2429	1904	1952	1096	350	283	492	357
Peterson	1619	2020	2186	1989	739	1227	1228	1079
Pope	3622	3351	4100	3989	653	581	557	644
Randolph	3791	3569	3195	2655	1627	1551	1884	1828
Reese	1809	806	644	0	866	926	459	0
Robins	3482	3224	3496	3797	770	745	823	846
Schriever	0	0	0	1449	0	0	0	712
Scott	4730	4440	4355	3773	2405	2163	2117	1678
Seymour-Johnson	4202	4121	4421	3840	617	581	576	557
Shaw	5431	4821	4929	4456	989	870	713	627
Sheppard	5891	5614	6619	6885	896	888	811	806
Tinker	6215	5533	6268	5265	1575	1481	1345	1089
Travis	6933	6340	7160	5907	1224	1238	1619	1341
Tyndall	3013	3753	4131	2947	834	778	812	823
USAF Academy	1855	1818	1598	1329	1195	1164	1396	1324
Vance	447	414	419	423	831	919	460	748
Vandenberg	3163	2700	2674	2627	810	712	752	783
Whiteman	2781	2729	2875	2970	480	476	325	310
Wright-Patterson	4196	4179	3358	2880	5363	5075	4045	2767
Yokota	3622	3747	3300	2990	602	672	612	564
Totals	294,839	270,521	272,717	245,196	72,579	69,982	65,424	59,519

APPENDIX F

List of Symbols, Abbreviations and Acronyms

LIST OF SYMBOLS, ABBREVIATIONS AND ACRONYMS

ACC	Air Combat Command
AFB	Air Force Base
AFIERA/RSRE	Air Force Institute for Environment, Safety and Occupational Health Risk Analysis, Environmental Sciences Branch
AFMC	Air Force Materiel Command
AMC	Air Mobility Command
ASCII	American Standard Code Information Interchange
BYEAR	Birth Year
CONUS	Continental United States
COTS	Commercial Off-The-Shelf
DAFSC	Duty Air Force Specialty Code
DAS	Date Arrived Station
DDI	Privacy Act Code
DEP	Dependent
DOB	Date Of Birth
E	Enlisted
E4	Senior Airmen
E5	Staff Sergeant
EPA	U.S. Environmental Protection Agency
ESSRA	Enhanced Site-Specific Risk Assessment
HQ AFMC	Headquarters Air Force Materiel Command
HQ AFMC/DPZD	Headquarters, Air Force Materiel Command, Data Automation and Analysis Branch
mg/kg	Milligram per Kilogram
mg/L	Milligram per Liter
mg/m^3	Milligram per Cubic Meter
MPF	Military Personnel Flight
MS	Microsoft
MSEF	Military-Specific Exposure Factors
MTC	Air Force Materiel Command
O	Officer
O3	Captain
O4	Major
OpTech	Operational Technologies Corporation
PACAF	Pacific Air Force
PCS	Permanent Change Of Station
SPC	Air Force Space Command
SSAN	Social Security Account Number
USAF	United States Air Force